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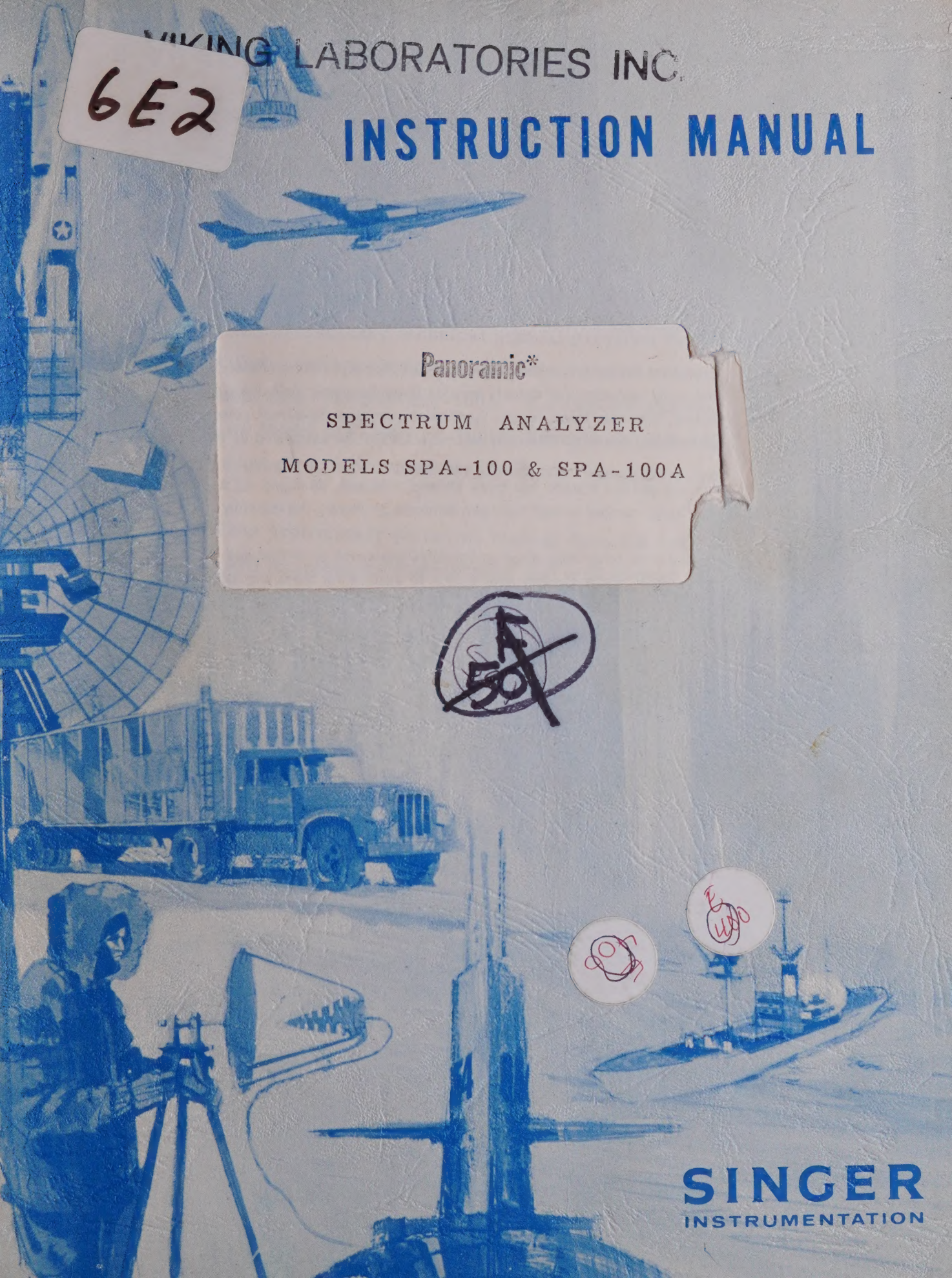
VIKING LABORATORIES INC.

INSTRUCTION MANUAL

Panoramic*

SPECTRUM ANALYZER

MODELS SPA-100 & SPA-100A



SINGER
INSTRUMENTATION

INSTRUCTION MANUAL

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Panoramic*

SPECTRUM ANALYZER

MODELS SPA-100 & SPA-100A

SINGER
INSTRUMENTATION

Precision electrical and electronic instruments for measurement

emc — EMPIRE — Gertsch — Panoramic — Sensitive Research

THE SINGER COMPANY • METRICS DIVISION

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3. Description of trouble(2)
4. Test instruments used
5. Approximate date instrument was placed in operation
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8. Other comments

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(2) Include data on symptoms, measurements taken, suspected location of trouble, maintenance action taken, and any other relevant data.

INTRODUCTION

This preliminary technical manual provides the general description, installation and operation instructions for Microwave Spectrum Analyzer Models SPA-100 and SPA-100A. A complete analyzer consists of Main Frame Model MF-100 and Tuning Head Model RF-100 or RF-100A. Separate manuals are provided for the Main Frame and for the Tuning Head.

This preliminary technical manual does not contain the theory of operation and maintenance instructions that will appear in the technical manual that is being prepared now to replace this preliminary manual. The operation section, contained in the Tuning Head preliminary manual, will be especially valuable to the user of the Spectrum Analyzer until the preliminary manual is replaced.

INSTRUCTION MANUAL

Panoramic*

TUNING HEAD

MODELS RF-100 & RF-100A

SINGER
INSTRUMENTATION

Precision electrical and electronic instruments for measurement

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SECTION I

INTRODUCTION

1-1. SCOPE OF MANUAL.

1-2. This instruction manual provides operating and maintenance instructions on PANORAMIC* Models RF-100 and RF-100A Tuning Heads, figure 1-1, manufactured by The Singer Company, Metrics Division, Bridgeport, Connecticut. The tuning heads are used in conjunction with Main Frame Model MF-100 to form either PANORAMIC Microwave Spectrum Analyzer Model SPA-100 or SPA-100A.

1-3. Although this manual covers the tuning head, it is assumed that the tuning head is mounted within a Main Frame. The Main Frame functions are discussed in a separate instruction manual.

1-4. The information contained in this manual refers only to the standard versions of Models RF-100 and RF-100A Tuning Heads and is current only to the date of publication. Differences in equipment components, specifications, and performance resulting from The Singer Company's continuous product improvement program or individual customer design and application requirements are described in addendum sheets.

1-5. PURPOSE AND USE OF EQUIPMENT.

1-6. The SPA-100 and SPA-100A are automatic scanning receivers that provide a CRT plot of received level versus frequencies of input signals. The analyzer rapidly measures the spectrum of input signals and graphically displays these spectra with scan dispersion (frequency window) adjustable to 100 MHz. The SPA-100 operates in the frequency range of 10 MHz to 11 GHz without accessories; the SPA-100A operates in the frequency range of 0.94 to 11 GHz without accessories. The frequency range of either model spectrum analyzer can be extended to 40 GHz with the use of external accessory waveguide mixers.

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(To Be Supplied)

Figure 1-1. Models RF-100 And RF-100A Tuning Heads And Accessories

1-7. The SPA-100 and SPA-100A contain built-in synchroscope circuits that provide an amplitude-versus-time display of the modulation of the rf signal to which the analyzer is tuned. Thus, the analyzer may be switched from a frequency-based to a time-based display to extend the usefulness of the instrument.

1-8. These analyzers are extremely useful for measuring and analyzing cw, am, fm, and pulsed signals. The following uses represent only a few of the many applications of the analyzers. Inquiries are invited regarding specific application problems.

a. Dynamic performance analysis of oscillators, signal generators, and transmitters.

b. Spectrum monitoring of communications channels and radar frequencies.

c. Analyzing pulsed signals.

d. Analyzing spectra associated with am, fm, and pm signals.

e. Direct reading of power peaks and nulls.

f. Studies of malfunctions in microwave equipment (e.g., spurious signals, instabilities, microphonic effects, etc.).

g. Factory calibration of production rf equipment.

h. Harmonic and other out-of-band measurements.

i. Examination of cw signals for frequency drift, incidental fm, and squegging.

j. Examination of dynamic operating characteristics of microwave tubes.

k. Checking for rf leakage and radiation.

l. Determining presence and frequency of rf signals.

m. As a sensitive receiver to measure characteristics of microwave components or circuits (e.g., insertion loss and vswr measurement).

n. Studies of noise spectra.

1-9. GENERAL DESCRIPTION.

1-10. The Tuning Heads are compact, receiver front-ends that fit into an area on the right side of the Main Frame front panel. The Tuning Head plus Main Frame comprise a spectrum analyzer that offers a wide range of sweep dispersions, sweep speeds, and i-f bandwidths for use in frequency and time-domain measurements. The Tuning Heads contain the tunable local oscillator (ceramic triode), the 1-11 GHz diode mixer, and the 160 MHz (i-f) solid state preamplifier. The i-f output of the preamplifier is applied to the Main Frame where it is further amplified, detected, and displayed on the calibrated CRT. The Model RF-100 contains, in addition, a solid-state fixed-frequency local oscillator and associated mixer that convert inputs in the frequency range of .01-1 GHz to signals in the range of 2.51 - 3.5 GHz; these up-converted signals are connected by an external jumper cable to the 1-11 GHz input. The up-converter technique results in a unique spurious-free wide dispersion display. In this way, the usable frequency coverage is available without reducing the maximum dispersion, even at the low end of the band. The local oscillator output is automatically maintained at a constant level so that the sensitivity does not vary resulting in improved gain stability over the full range.

1-11. SPECIFICATIONS.

1-12. Table 1-1 lists the electrical and physical characteristics of the tuning heads. These characteristics include those of the Main Frame since the Main Frame characteristics are largely influenced by the tuning head with which it is used.

1-13. ACCESSORY ITEMS SUPPLIED.

1-14. The accessories available for use with the Tuning Heads are described in table 1-2 and illustrated in figure 1-1.

1-15. TRANSISTOR, DIODE, AND ELECTRON TUBE COMPLEMENT.

1-16. The transistors, diodes and electron tubes used in Models RF-100 and RF-100A are listed in table 1-3. Items that are used only in Model RF-100 are marked with asterisks.

TABLE 1-1. SPECIFICATIONS

Frequency range:	
SPA-100	0.01 to 40 GHz
SPA-100A	0.94 to 40 GHz
Minimum sensitivity (S + N = 2N at 1 kHz i-f bandwidth)	- 90 dbm, .01- 1 GHz -110 dbm, .94- 3.5 GHz -105 dbm, 3.2 -11 GHz - 90 dbm, 11. -18 GHz - 80 dbm, 18 -26 GHz - 75 dbm, 26 -40 GHz
Image separation	320 MHz
I-F Bandwidth	Calibrated: 1, 3, 10, 30, 100, 1000 kHz Uncalibrated: Continuously adjustable from 1 to 100 kHz Automatic: Dispersion switch automatically selects bandwidth for optimum cw resolution
I-F attenuation	0 to 69 dB in 1 dB steps accuracy 0.1 dB/dB
Variable I-F gain	20 dB minimum
I-F markers (auto-calibration)	160 MHz with internal (1 or 10 MHz) or external marker modulation
Sweep modes	Internal, external (-5v to +5v minimum for full sweep), manual, and single sweep.

TABLE 1-1. SPECIFICATIONS (Cont)

Sweep Speeds	Calibrated steps: 10 usec/div to 1 sec/div in 1, 3, 10 sequence Uncalibrated: continuously adjustable between calibrated steps.
Sweep synchronization	Free-running, internal video, external (+3v peak, min.), line.
Dispersion	Calibrated steps: 0, 10, 30, 100, 300 kHz, 1, 3, 10, 30, 100 MHz Accuracy: ±5% Uncalibrated: continuously adjustable between calibrated steps.
Display area	7.5 cm x 10 cm on aluminized P31 phosphor CRT
Vertical scales	Log: 60 dB (on screen), ±2 dB cw and pulse Linear: Relative voltage, ±3% full scale Power (square law): Relative power, ±5% full scale
Intensifier	Base line clipper for brighter display of narrow pulses
Video filtering	Tracked with variable bandwidth; independently adjustable in the calibrated bandwidth positions

TABLE 1-1. SPECIFICATIONS (Cont)

Auxiliary outputs: vertical horizontal	 0 to 1v into 1000 ohms -.5 to +.5v into 1000 ohms
Power requirements	115 or 230v +10%, single phase 47 - 440 Hz, 80 watts
Dimensions	16 - 3/4" wide x 8 - 23/32" high x 19" deep
Weight	65 lbs

TABLE 1-2. ACCESSORY ITEMS

Figure 1-1 Index No.	Description	Part No.	Use
1	RF Attenuator Set Assembly AT-100	102-0105-001	Three attenuators used in series with the signal to introduce 10.0 ±1.25 dB, 20.0 ±1.5 dB, and 30.0 ±2.0 dB. Can be used in combinations to provide 10, 20, 30, 40, 50, or 60 dB. These attenuators are used in the range of 0 - 11.0 GHz.
2	Low-pass Filter	556147-008	In the .01 to 1 GHz band, it reduces local oscillator conduction out of the SIGNAL INPUT jacks by greater than 60 dB.
3	Accessory Cover Assembly CMF-100	102-0108-001	Provides convenient storage of accessories that are not in use.

TABLE 1-2. ACCESSORY ITEMS (Cont)

Figure 1-1 Index No.	Description	Part No.	Use
4	Waveguide Mixer Ku-100	102-0104-001	External waveguide mixer that is connected to RF-100 or RF-100A Tuning Head to allow its use in frequency range of 11-18 GHz.
5	Waveguide Mixer K-100	102-0103-001	External waveguide mixer that is connected to RF-100 or RF-100A Tuning Head to allow its use in frequency range of 18-26 GHz.
6	Waveguide Mixer Ka-100	102-0102-001	External waveguide mixer that is connected to RF-100 or RF-100A Tuning Head to allow its use in frequency range of 26-40 GHz.

TABLE 1-3. TRANSISTOR, DIODE, AND ELECTRON TUBE COMPLEMENT

Ref. Desig.	Type	Function
CR1	1N3011	Zener regulator
CR2	1N2974	Zener regulator
A1CR1	1N1132	1-11 GHz mixer
A2Q1	FT-45	160 MHz preamplifier
A3V1	Y1610	Tunable local oscillator
A5Q1	FT-45	160 MHz preamplifier
A6CR1	1N4514	Temperature compensation
A6Q1	2N3440	Cathode bias regulator for A3V1
A6Q2, Q3	2N3694	Difference amplifier
A7CR2*	MA417	.01-1 GHz mixer
A8CR1*	0112	Harmonic generator
A8Q1*	2N4427	Buffer amplifier
A9A1Q1*	2N3563	Crystal oscillator
A9A1Q2*	2N3641	Buffer amplifier
A9A2Q1*	2N3866	Frequency tripler

*Used only in Model RF-100

SECTION II

OPERATION

2-1. GENERAL.

2-2. This section contains operating instructions for the Model SPA-100 and Model SPA-100A Spectrum Analyzers. A complete Model SPA-100 Spectrum Analyzer comprises one Model RF-100 Tuning Head and the Model MF-100 Main Frame; a complete Model SPA-100A Spectrum Analyzer comprises one Model RF-100A Tuning Head and the Model MF-100 Main Frame.

2-3. INSTALLATION.

2-4. The Spectrum Analyzer is shipped with the Tuning Head and Main Frame integrated to form a single unit. All power inputs and connections other than the signal input connections are already established. Installation of the Main Frame is described in the Main Frame manual.

2-5. OPERATOR'S CONTROLS, INDICATORS, AND CONNECTORS.

2-6. The operator's controls and indicators of the Spectrum Analyzer are listed in table 2-1 and illustrated in figure 2-1.

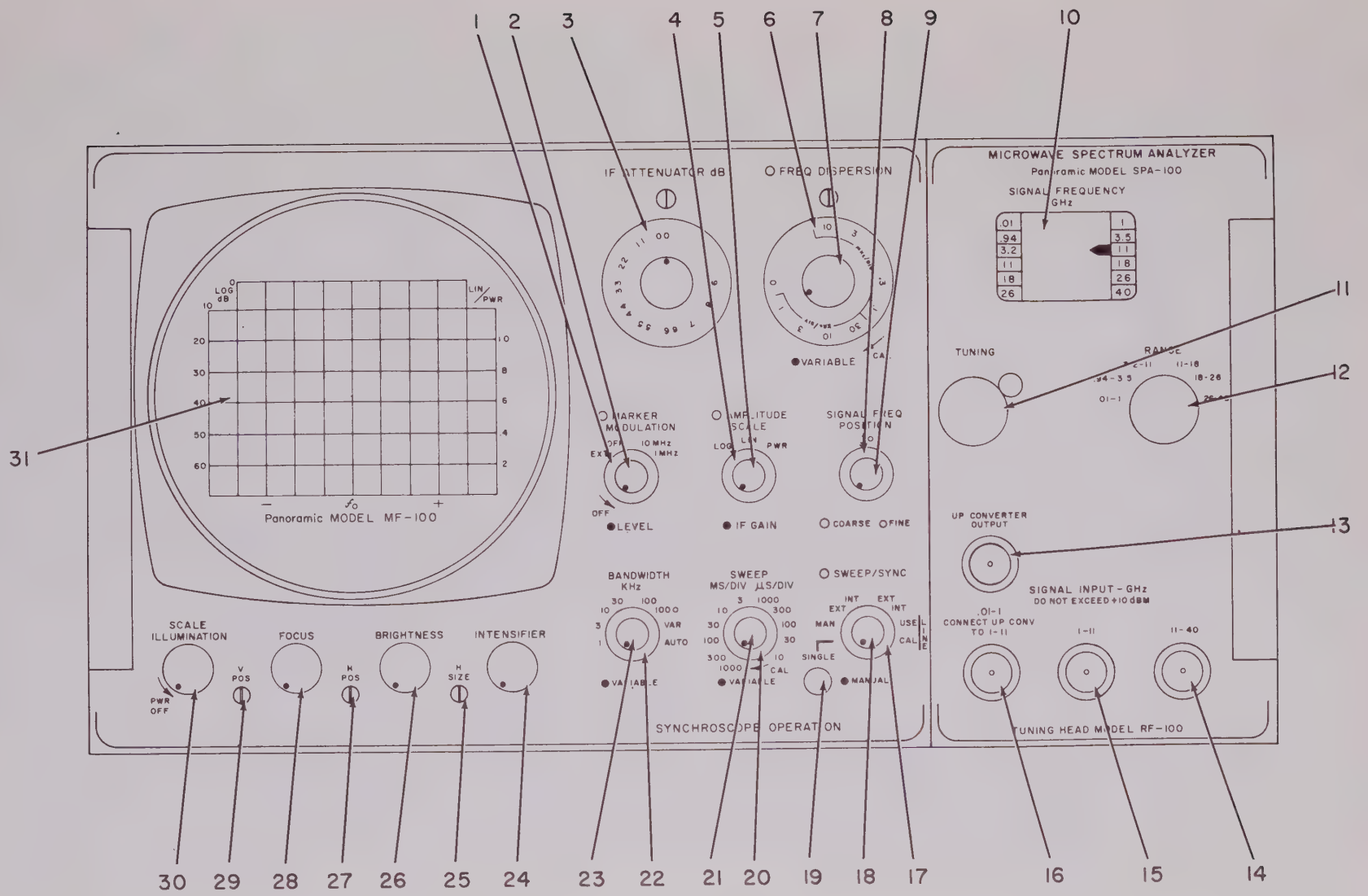


Figure 2-1. Model SPA-100, Operator's Controls and Indicators

TABLE 2-1. OPERATING CONTROLS AND INDICATORS

Figure 2-1 Index No.	Control or Indicator	Function
1	MARKER MODULATION switch (outer control)	Selects markers on display as follows: EXT - connects external input as marker modulating signal. Markers appear at intervals equal to the external input frequency. OFF - removes marker modulation from display. 10 MHz - selects markers spaced at 10 MHz intervals either side of the center frequency. 1 MHz - selects markers spaced at 1 MHz intervals either side of the center frequency.
2	LEVEL control (inner control)	Adjusts the level of selected markers. OFF position turns center frequency marker off.
3	AMPLITUDE SCALE switch (outer control)	Selects linear power or linear voltage-amplitude presentation (scale calibrated from 0 to 1.0 in 0.2 increments) or logarithmic presentation (scale calibrated in 0 to -60 dB in 10 dB increments).

TABLE 2-1. OPERATING CONTROLS AND INDICATORS (cont)

Figure 2-1 Index No.	Control or Indicator	Function
4	IF ATTENUATOR dB switch	Selects resistive attenuators at i-f input. The tens dial and units dial are superimposed; the tens dial is engraved with digits 0 through 6, the units dial with digits 0 through 9. The digits on the tens dial are intentionally placed slightly left of those on the units dial to create a two-digit number. For example, rotating the tens dial could change the attenuation reading (in dB) from 18 to 28 to 38, etc; rotating the units dial could change the reading from 38 to 37 to 36, etc.
5	IF GAIN control (inner control)	Vernier-adjusts over-all IF gain, thereby enabling calibration of the selected amplitude scale against a reference input.
6	FREQ DISPERSION switch (outer control)	Selects the dispersion of the frequency window displayed on the CRT. When the BANDWIDTH switch is set to AUTO, the FREQ DISPERSION switch setting automatically establishes the optimum bandwidth for CW type signals as follows:

TABLE 2-1. OPERATING CONTROLS AND INDICATORS (cont)

Figure 2-1 Index No.	Control or Indicator	Function
6 (cont)		Dispersion Setting / Optimum Bandwidth 0, 1, 3, 10 kHz/div — 1 kHz 30 kHz/div — 3 kHz .1 MHz/div — 3 kHz .3, 1 MHz/div — 10 kHz 3, 10 MHz/div — 30 kHz
7	FREQ DISPERSION VARIABLE control (inner control)	Reduces the dispersion of the frequency window displayed on the CRT below the value indicated on the FREQ DISPERSION switch to expand the presentation and allow closer examination of a particular signal. When the control is set fully clockwise, the dispersion corresponds to the FREQ DISPERSION switch position marking.
8	SIGNAL FREQ POSITION fo COARSE control (outer control)	Coarse-adjusts the frequency that corresponds to the center of the display so that a particular signal can be centered in thedisplay (superimposed with the center graticule line). This control is effective in each position of the FREQ DISPERSION switch.
9	SIGNAL FREQ POSITION fo FINE control (inner control)	Fine-adjusts the frequency that corresponds to the center of the display. This control is effective in all positions of the FREQ DISPERSION switch except the 1, 3, and 10 MHz/DIV positions; in these positions, the extent of the fine adjustment would be too slight to be noticeable.

TABLE 2-1. OPERATING CONTROLS AND INDICATORS (cont)

Figure 2-1 Index No.	Control or Indicator	Function
10	SIGNAL FREQUENCY GHz dial	Indicates the center frequency (in GHz) to which the Spectrum Analyzer is tuned. Index pointer indicates the scale to be read in accordance with SIGNAL FREQUENCY RANGE GHz switch setting.
11	SIGNAL FREQUENCY GHz TUNING control	Tunes spectrum analyzer to the desired input signal frequency within the selected band.
12	SIGNAL FREQUENCY GHz RANGE switch	Selects one of the tuning bands for the Analyzer. The bands (in GHz) are: .01 - 1* .94 - 3.5 3.2 - 11 11 - 18 18 - 26 26 - 40
13	UP CONVERTER OUTPUT connector*	Provides the converted output of low-frequency input signals connected to SIGNAL INPUT .01 -1 GHz connector. The converted signals (in the range of 2.51 to 3.5 GHz) are connected to the normal SIGNAL INPUT 1-11 GHz connector.

* Model SPA-100 only

TABLE 2-1. OPERATING CONTROLS AND INDICATORS (cont)

Figure 2-1 Index No.	Control or Indicator	Function
14	SIGNAL INPUT 11-40 GHz connector	Input connector for signals in the range of 11 to 40 GHz. External accessory waveguide mixers are required for inputs in this frequency range. The input signal is connected to the waveguide mixer and the output of the mixer is connected to the SIGNAL INPUT 11-40 GHz connector.
15	SIGNAL INPUT 1-11 GHz connector	Input connector for signals in range of 1 to 11 GHz. When signals in the frequency range .01-1 GHz* are applied to the Analyzer, the up converter output is applied to this connector.
16	SIGNAL INPUT .01-1 GHz connector*	Input connector for signals in the range of .01 to 1 GHz.
17	SWEEP/SYNC switch (outer control)	Controls CRT sweep with left-side positions pertaining to sweep and right-hand positions to sync as follows: SINGLE - Enables the SINGLE pushbutton (19) to initiate a single sweep. MAN - Enables the MANUAL sweep control (18) to control the sweep.

* Model SPA-100 only

TABLE 2-1. OPERATING CONTROLS AND INDICATORS (cont)

Figure 2-1 Index No.	Control or Indicator	Function
17 (cont)		EXT (black) - CRT (frequency) sweep produced by an external signal applied at J1-E (rear of Main Frame). INT (black) - Frequency sweep is "free-running". EXT (red) - Allows sweep to be triggered by an external signal applied at J1-D (rear of Main Frame). INT (red) - Allows the detected video to trigger the sweep. USE - Synchronizes the sweep to the line frequency. CAL - Allows the video and sweep circuits to be calibrated against a voltage derived from the power line.

TABLE 2-1. OPERATING CONTROLS AND INDICATORS (cont)

Figure 2-1 Index No.	Control or Indicator	Function
18	MANUAL sweep control (inner control)	Adjusts the horizontal position (frequency) of the CRT spot allowing a selected position of the sweep to be scanned manually. This control is effective only when the SWEEP/ SYNC switch is in MAN.
19	SINGLE sweep pushbutton	Initiates a single sweep (useful in photography) when the SWEEP/SYNC switch (17) is in the SINGLE position.
20	SWEEP switch (outer control)	Selects sweep rates for analyzer and synchroscope operation. For optimum scanning speed when the BANDWIDTH switch is set to AUTO, the SWEEP switch should be set to 10 MS/DIV.
21	SWEEP VARIABLE control (inner control)	Reduces the sweep rate below the value indicated on the SWEEP switch; when the control is set fully clockwise, the sweep rate corresponds to the SWEEP switch position marking.
22	BANDWIDTH switch (outer control)	Selects fixed values of the IF bandwidth (which affects resolution of adjacent signals as displayed on the CRT) between 1 and 1000 kHz in the first six positions; allows continuous variation of the bandwidth in the VAR position; enables automatic selection of the optimum bandwidth (by the FREQ DISPERSION switch) in the AUTO position.

TABLE 2-1. OPERATING CONTROLS AND INDICATORS (cont)

Figure 2-1 Index No.	Control or Indicator	Function
23	BANDWIDTH VARIABLE control (inner control)	Provides continuous, uncalibrated control of IF bandwidth between 1 and 100 kHz when the BANDWIDTH switch (15) is set to VAR; provides continuous control of video filtering in 1, 3, 10, 30, and 100 kHz switch positions.
24	INTENSIFIER control	Allows the video pulses to be intensified while the baseline and low-level noise pulses are blanked.
25	H SIZE adjustment	Adjusts the physical length of the trace.
26	BRIGHTNESS control	Adjusts the intensity of the CRT display.
27	H POS adjustment	Adjusts the horizontal positioning of the trace.
28	FOCUS control	Adjusts the focusing of the CRT display.
29	V POS adjustment	Adjusts the vertical positioning of the trace.
30	SCALE ILLUMINATION control	Adjusts the illumination of the graticule lines. This control incorporates the power switch; when rotated clockwise from the PWR OFF position, power is applied to the analyzer.

TABLE 2-1. OPERATING CONTROLS AND INDICATORS (cont)

Figure 2-1 Index No.	Control or Indicator	Function
31	CRT display	A CRT with a calibrated graticule scale containing 11 horizontal divisions and 7 vertical divisions. The calibrations for the vertical scale are controlled by the AMPLITUDE SCALE switch (3); the horizontal scale by the FREQ DISPERSION controls (6 and 7) in analyzer operation and by the SWEEP switch (20) in synchroscope operation.

2-7. SUMMARY OF OPERATING PROCEDURES.

2-8. The procedures contained in the following paragraphs of this section are primarily concerned with the operation of Model SPA-100 Spectrum Analyzer. The operating procedures for Model SPA-100A Spectrum Analyzer differ only in the absence of the 0.01 to 1 GHz tuning range.

2-9. TURN-ON PROCEDURES.

2-10. To turn on the Spectrum Analyzer, check that equipment is set up properly in accordance with primary power used; then turn BRIGHTNESS and INTENSIFIER controls fully counterclockwise and turn SCALE ILLUMINATION control clockwise until the CRT graticule illuminates. Operating voltages are now applied to all circuits of the Main Frame and associated Tuning Head.

2-11. Slowly turn BRIGHTNESS control clockwise and observe the CRT. A trace should be visible. Adjust BRIGHTNESS and FOCUS controls to obtain

a sharp, well-defined trace, as desired. If a trace is not visible, refer to Section IV for maintenance instructions. If necessary, adjust V POS screwdriver control until the trace coincides with the lowest graticule line.

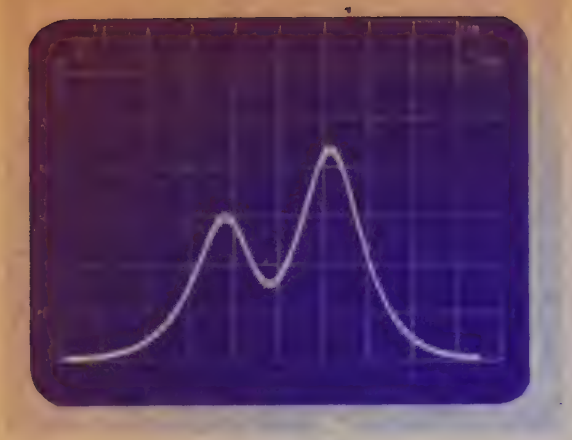
2-12. GENERAL OPERATING PROCEDURES. (figure 2-2)

2-13. SCANNING PROCEDURE. To scan the frequency spectrum, follow the procedure given below:

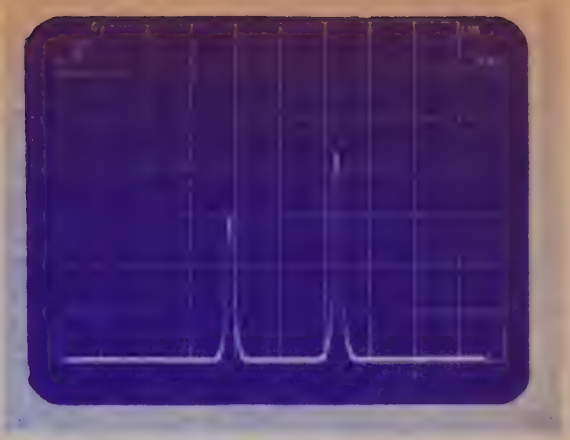
a. Set the analyzer controls to the positions listed below:

Control	Position
IF ATTENUATOR switches	00
FREQ DISPERSION switch	10 MHz/DIV
MARKER MODULATION switch	OFF
LEVEL control	CW
AMPLITUDE SCALE switch	LOG
IF GAIN control	Until noise is one division high
BANDWIDTH switch	100 kHz
BANDWIDTH VARIABLE control	CW
SWEEP switch	10 MS/DIV
SWEEP/SYNC switch	INT SWEEP (black)
SIGNAL FREQ POSITION controls	To center the center marker

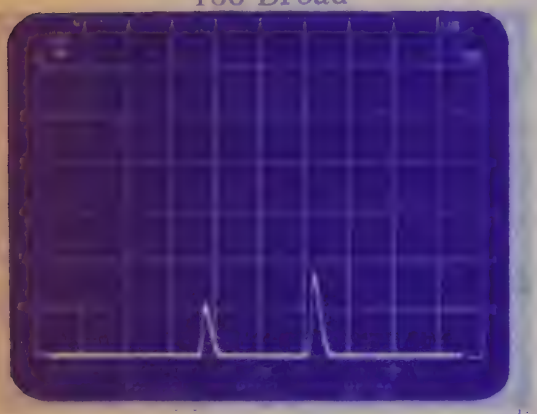
b. Set the RANGE switch on the tuning head to the desired frequency range. Note that the index on the SIGNAL FREQUENCY dial indicates the selected range.



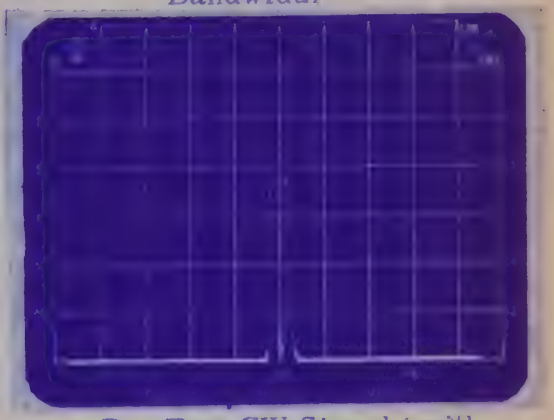
A. Bandwidth Too Broad



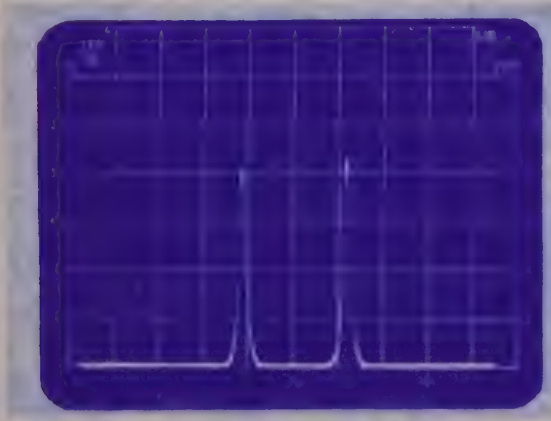
B. Optimum Bandwidth



C. Bandwidth Too Narrow



D. Two CW Signals with Excessive Frequency Dispersion



E. Same DW Signals with Proper Frequency Dispersion

Figure 2-2. Effects of Operating Controls on Display

c. Set the TUNING control on the tuning head until the lowest frequency in the selected range appears in the SIGNAL FREQUENCY dial.

d. While observing the CRT display, turn the TUNING control clockwise.

e. As signals appear, adjust the amplitude as necessary by using the IF ATTENUATOR switch.

NOTE

The signal input to the tuning head should not exceed -30 dbm. Signal amplitudes above this level will result in distortion and in the generation of spurious signal pips on the CRT display.

2-14. OBTAINING DESIRED RESOLUTION. At wide bandwidths, input signals having a small frequency difference tend to merge into and mask each other. The ability of the equipment to separate individual signals depends upon two factors: the scanning velocity (product of the sweep rate and the frequency dispersion) and the bandwidth of the intermediate frequency (IF) section of the analyzer. For any given scanning velocity, there is a corresponding bandwidth for optimum resolution. The scanning velocity is reduced by decreasing the frequency dispersion that is scanned by each sweep or by decreasing the sweep speed. Reducing the bandwidth improves the resolution (the ability of the equipment to separate closely spaced frequency components). If the frequency of a signal of small amplitude is close to the frequency of a large amplitude signal, the smaller pip will be masked by the amplitude of the skirt of the

larger pip (the amplitude-versus-frequency response of the IF section being bell-shaped). As the frequency separation of the signals increases, or the resolution of the analyzer increases, the individual signal characteristics error becomes less.

2-15. When the CRT displays a wide frequency spectrum, a group of closely spaced signals such as a carrier and its sidebands may appear almost as a single pip. To examine a group of signals such as this more closely, center the signals in the CRT display using the TUNING control, and decrease frequency dispersion using the FREQ DISPERSION switch. Further improvement in the resolution may be achieved by setting the BANDWIDTH switch at VAR and adjusting the BANDWIDTH VARIABLE control until the best resolution is achieved. Narrowing the IF bandwidth improves resolution until a point of optimum resolution is reached. Further narrowing of the IF bandwidth without correspondingly decreasing the scanning velocity effects no further improvement for CW or narrow band signals, but causes a severe reduction in amplitude for pulsed or wideband signals (resulting from the inability of the IF amplifier to respond rapidly enough), producing a decreased sensitivity.

NOTE

When the BANDWIDTH switch is set to AUTO and the SWEEP switch is set at 10 MS/DIV, the FREQ DISPERSION switch setting automatically selects a value for the IF BANDWIDTH which results in optimum resolution for CW and narrowband signals. In this way the bandwidth is controlled according to the scanning velocity.

2-16. Another way to obtain better resolution is to decrease the sweep speed (rotate the SWEEP switch counterclockwise). The choice of the appropriate sweep speed is determined by the nature of the signal being studied. For example, when the test signals are sporadic, it is desirable to operate at high sweep speeds to increase the probability of intercepting the signal. When examining pulse spectra, increasing the sweep speed will reduce the number of pulse lines per scan if the PRF is less than the IF bandwidth. When the PRF is greater than the IF bandwidth, the number of lines is constant, regardless of sweep speed.

2-17. To increase the resolution capabilities by reducing FREQUENCY DISPERSION, narrowing the IF bandwidth, and increasing the scanning time, the following procedure is used:

a. Set the BANDWIDTH switch to VAR and the BANDWIDTH VARIABLE control completely clockwise for maximum IF bandwidth (approximately 100 kHz).

b. Adjust the TUNING and SIGNAL FREQ POSITION controls so that the desired band of signals is at the center of the screen.

c. Spread the band of signals across the screen by reducing the frequency dispersion with the FREQ DISPERSION switch. Turn the BANDWIDTH VARIABLE control counterclockwise until individual signals are clearly resolved. If the signals cannot be resolved, a slower sweep speed is required. If the BANDWIDTH VARIABLE control is set beyond the point of optimum resolution, a severe loss of amplitude results for pulsed and wideband signals and the left-hand side of the signal pips appear to be stretched.

NOTE

If it is necessary to observe a given bandwidth with the contained signals closely spaced, the best possible resolution is indicated by the clearest picture. A reasonably accurate measurement of relative amplitudes can be made by reading the center of the beat notes between the adjacent signals.

2-18. For certain types of signals it is desirable to observe the envelope of the pulse spectrum rather than the individual lines. This would be the case when observing rf pulses at low prf's or when observing noise. If individual lines are present in the spectrum, increase the IF bandwidth by rotating the BANDWIDTH switch clockwise until only the envelope can be discerned. To examine the envelope of a noise signal, set the BANDWIDTH switch at 100 kHz and rotate the BANDWIDTH VARIABLE control (video filtering) counterclockwise until only the envelope is displayed.

2-19. ZERO FREQUENCY PIP. When Model SPA-100 is operated near the low end of its lowest frequency range, the zero frequency pip will appear on the CRT display. The sweep to the left of the zero frequency pip is not calibrated and no information should be inferred from the appearance of any pip in this region.

2-20. PHOTOGRAPHY. When it is desirable to create a permanent record of the analyzer display, connect a Polaroid camera adapter to the CRT bezel and adjust the analyzer until a desired display is achieved. Set the SWEEP/

SYNC switch to SINGLE, open the aperture, and depress the SINGLE push-button. To adjust the intensity and exposure time, adjust the intensity and sweep rate.

2-21. PRE-OPERATING CHECKS.

2-22. The following procedure determines quickly that the equipment is operating normally:

a. Set the analyzer controls as listed in paragraph 2-13a.

b. Set the MARKER MODULATION switch to 10 MHz, the LEVEL control MAXIMUM cw, and the SWEEP/SYNC switch to INT (black). Set the FREQ DISPERSION switch to each of its positions and note that the displacement of the markers and the width of the center marker increase as the frequency dispersion increases.

c. Set the FREQ DISPERSION switch to 10 kHz/DIV and set the BAND-WIDTH switch to each of its positions. Note that the width of the center marker increases as the bandwidth is increased.

d. On the Model SPA-100 Spectrum Analyzer, connect the UP CONVERTER OUTPUT to the 1-11 connector and set the SIGNAL FREQUENCY RANGE switch to .01-1. Adjust the TUNING control until the SIGNAL FREQUENCY dial is set at 0. The zero frequency pip should appear centered on the CRT display. Adjust the IF ATTENUATOR controls and note that the zero frequency pip amplitude varies accordingly.

2-23. INPUT SIGNAL IDENTIFICATION.

2-24. INPUT SIGNAL CLASSIFICATION. In general, input signals to the spectrum analyzer may be divided into two types; discrete and non-discrete. Discrete signals are in the form of periodic waveforms with frequency contents which do not vary appreciably with time. The internally generated markers are typical of such a signal. Although the marker output consists of several harmonic frequency components, each frequency is discernible as a separate marker pip on the CRT screen (provided the spectrum analyzer resolution is proper for the frequency difference encountered). In practice, discrete signals are typical of periodic oscillation such as modulated or unmodulated signal generator and oscillator outputs.

2-25. Non-discrete signals are typified by random noise in which the input frequency distribution is spread out over a band of the spectrum rather than consisting of line spectra. Non-discrete signals are displayed on the spectrum analyzer as a varying envelope of amplitude at each spectrum sample. The three amplitude scales are equally valid for both random and discrete signals. However, the equipment sensitivity for discrete signals is different from that for random signals. Discrete signal levels should be compared to other discrete signal levels, and random signal levels to other random signal levels when relative signal strengths are being determined.

2-26. INTERPRETATION OF TYPICAL SCREEN PRESENTATIONS. With a little experience, the operator will be able to visually recognize the character of the various types of signals.

a. A constant carrier signal appears as a deflection of fixed height with the width of the presentation depending upon the frequency dispersion and IF bandwidth. If the scanning velocity is not too high, the presentation is the frequency response curve of the IF amplifier. The width of this presentation is proportional to the ratio of the IF bandwidth to the frequency dispersion. (See figure 2-3 A) Deviations of the signal from true cw will result in displays which will indicate the character of the signal as follows:

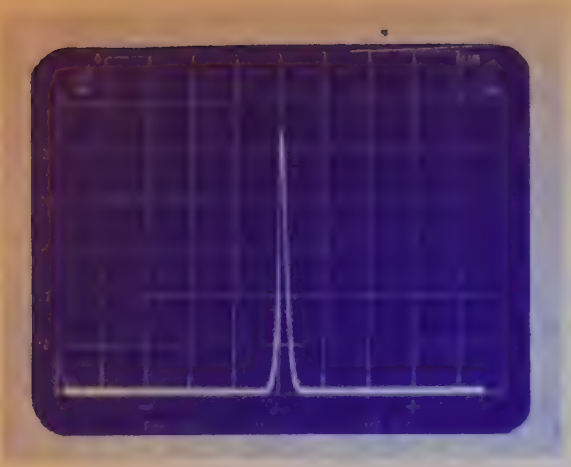
(1) Oscillator drift - deflection moves slowly across the screen.

(2) Periodic drift - deflection moves back and forth across the screen.

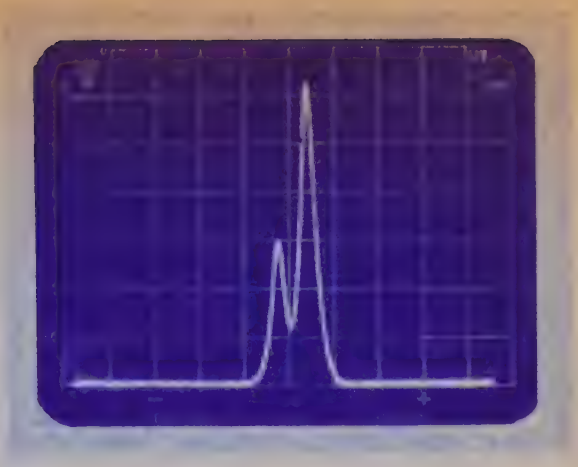
(3) Squegging - interruption of an oscillator at AF or IF rate will result in a spectrum display resembling a pulse modulated signal. Sideband components will be present in lobes either side of the oscillating frequency.

(4) Incidental FM - unintentional frequency modulation of a carrier that is produced by the amplitude-modulating signal and causes the carrier and sideband pips to appear to jitter on the CRT display.

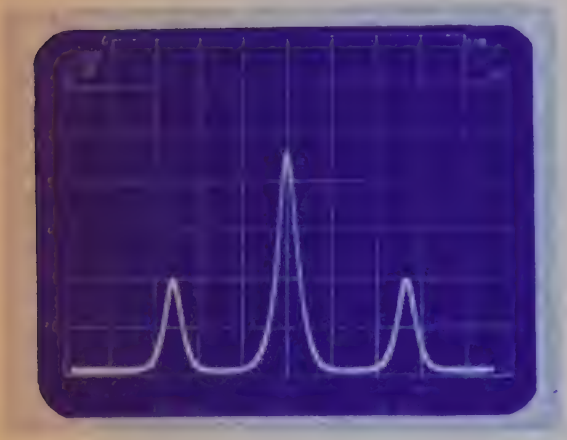
b. Two cw signals which are so close in frequency as to cause aural interference (beats) may appear on the screen as a single signal whose height varies with modulation. As the frequency separation is increased, the signal appears to be modulated on one side only. Further separation will cause a dip at the apex of the deflection. By improving the resolution of the analyzer, the two signals will gradually separate. (See figure 2-3B.)



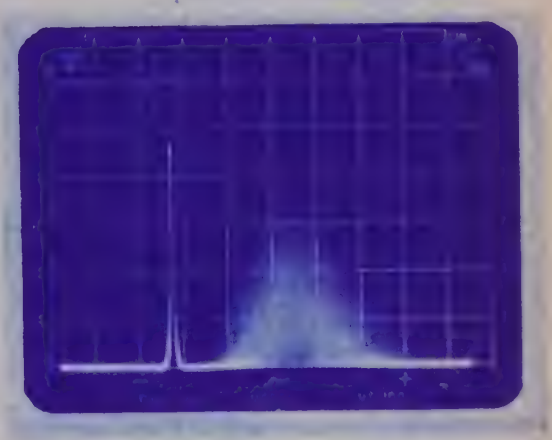
A. CW Signal



B. Two Interfering Carriers at Optimum Resolution

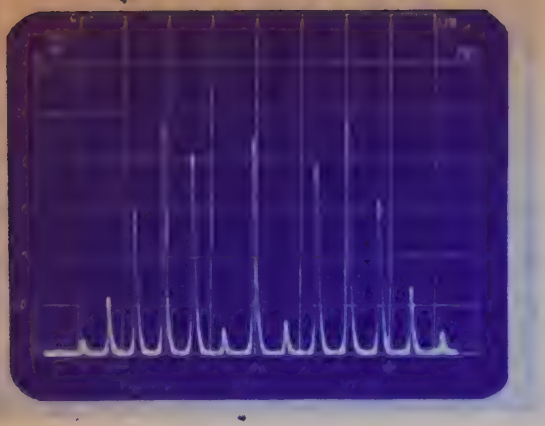


C. Amplitude-Modulated Signal with Carrier at the Center and Two Sidebands

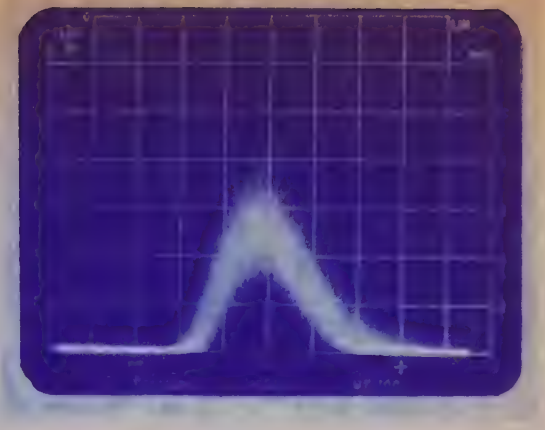


D. Single-sideband Signal Without Suppressed Carrier

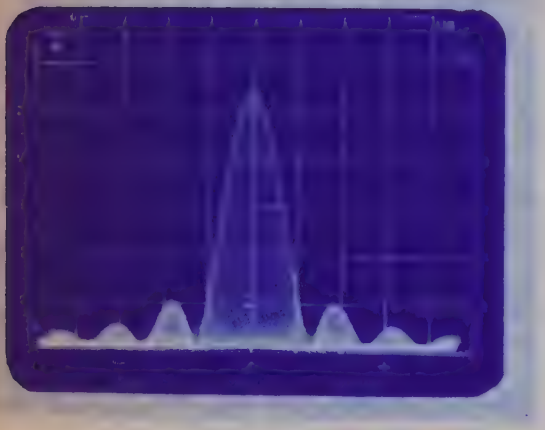
Figure 2-3. Typical CRT Presentations of Discrete Signals (Sheet 1 of 2)



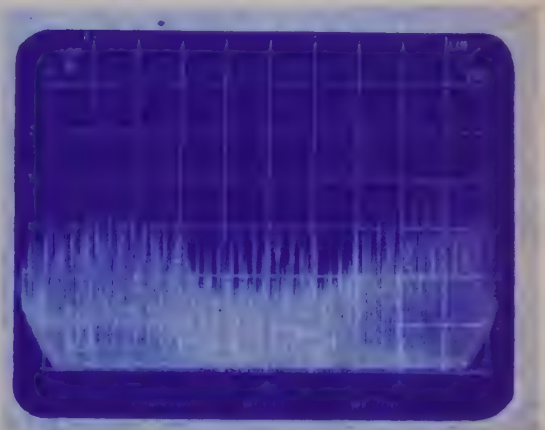
E. Frequency-Modulated Signal



F. Typical Sideband Energy of f-m Signal, Speech Modulated (slow sweep used to display envelope averages)



G. Pulsed rf Signal



H. Signals Generator Output

Figure 2-3. Typical CRT Presentations of Discrete Signals (Sheet 2 of 2)

c. An amplitude-modulated carrier appears as a deflection of variable height, when the modulating frequency is very low. Non-constant tone modulation of low frequency will produce a series of convolutions varying in height along the sides of the carrier pip. As the modulation frequency increases, the convolutions move toward the two sides of the deflection, and the sidebands become visible. It becomes possible to separate the sidebands by reducing the frequency dispersion of the analyzer. The BANDWIDTH control will enable further signal resolution. The higher the frequency of modulation, the greater the separation between the sidebands and the center deflection, which represents the carrier. (See figure 2-3C.)

d. The appearance of single-sideband signals depends upon the type of modulation employed. Tone-modulated single-sideband signals appear as a carrier (for a single tone), or a series of carriers (for multi-tones) of slightly different frequency. Voice or music-modulated single-sideband signals appear as a "smear" of rapidly varying signals which occupy finite bandwidth. A typical screen presentation of an amplitude-modulated single-sideband signal without carrier suppression is shown in figure 2-3D.

e. Frequency-modulated carriers appear as a series of vertical deflections. (See figure 2-3E.) The spectral lines are spaced from the carrier at multiples of the modulating frequency. A carrier that is frequency-modulated at a low rate appears as a carrier that wobbles sideways. The vertical deflections shift rapidly when the carrier is modulated by voice or music. (See figure 2-3F.)

f. A pulse-modulated signal (figure 2-3G) will consist of a pattern of vertical spikes. The number of spikes is dependent on the pulse repetition rate, and the IF bandwidth and the sweep rate of the equipment. The amplitude of each spike represents the amount of energy present at that particular frequency during one of the pulses. The peak envelope of all the spikes represents the energy-distribution pattern of the signal.

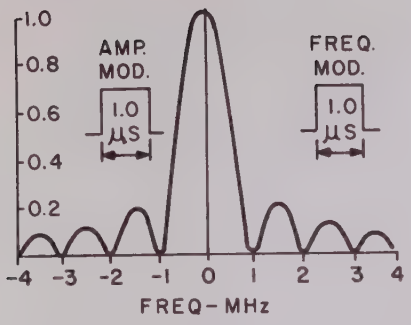
g. An impulse generator produces a train of very narrow pulses at a relatively low prf. The spectrum, an exaggerated pulsed rf display, consists of an extremely broad (and therefore essentially flat) central lobe with very closely spaced spectral lines. (See figure 2-3H.)

h. Radio interference signals of various types may appear on the screen of the spectrum analyzer. Such signals may have broad or narrow spectral distributions, and may occur at constant or at random repetition rates. Signals which occur at a variable repetition rate (such as those produced by accelerating motors, vibrators, buzzers, etc.) may move in one direction or the other along the frequency sweep baseline; that is caused by the fact that the analyzer is sweeping at a fixed rate, whereas the observed signal occurs at a variable rate. The pips stand still on the screen when there is synchronism between the two. Signals produced by such sources as electrical arcing, switching transients, "static," and other short electrical impulses, have broad spectra which may cover the entire frequency range of the analyzer.

2-27. CHARACTERISTICS OF PULSED RF DISPLAYS. Because the examination of pulsed r f signals represents an important application for spectrum

analyzers, it is well to consider the characteristics of these signals and their appearance on the analyzer display. The pulse that modulates the r f carrier contains as its frequency components the pulse repetition frequency and its harmonics. The pulsed rf signal therefore consists of a carrier frequency and sideband frequencies spaced at the pulse repetition frequency of the modulating pulse. Thus the higher the pulse repetition frequency, the greater the spacing between adjacent sideband spectral lines. The frequency between the carrier and the first null is equal to the reciprocal of pulse width of the modulating pulse. Thus the width of the main lobe is equal to 2/pulse width. Thus as the pulse width increases, the width of the main lobe on the analyzer display decreases. The frequency between adjacent null points is equal to the frequency between the carrier frequency and the first null; the width of the side lobes is therefore half the width of the main lobe and is 1/pulse width. Figure 2-4 illustrates typical pulsed rf displays. Figure 2-4A shows a perfect pulsed rf signal; the spectrum is characterized by equal upper and lower sidebands and by the null points reaching to the baseline. When the amplitude of the pulse varies during the time of the pulse, the upper and lower sidebands are lower in amplitude and spread apart; this is shown in figure 2-4D. If the carrier frequency varies during the time of a pulse, the null points no longer reach to the baseline as shown in figure 2-4B. F igure 2-4E shows the effect of amplitude and frequency modulation in a pulsed rf signal.

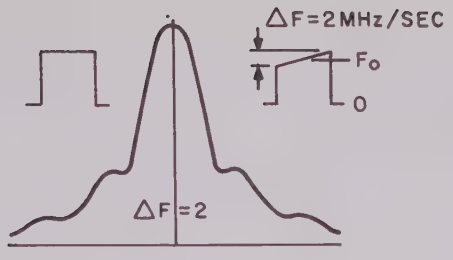
2-28. The actual spectral lines for a repetitive pulse can be observed on an analyzer when the pulse repetition rate is greater than the resolution capability



Spectrum of rectangular pulse without AM or FM occurring during pulse.

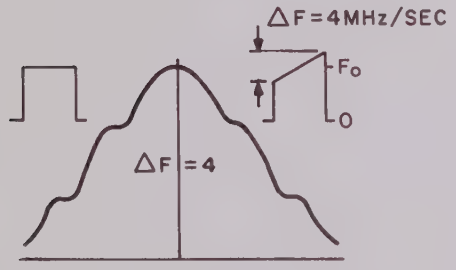
Shape is that of $\frac{\sin \frac{\omega\tau}{2}}{\frac{\omega\tau}{2}}$ function.

A.



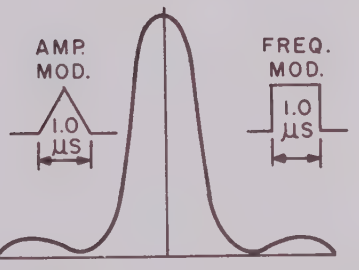
Spectrum of rectangular pulse with linear FM resulting in increased sidelobe amplitude and minimas not reaching zero.

B.



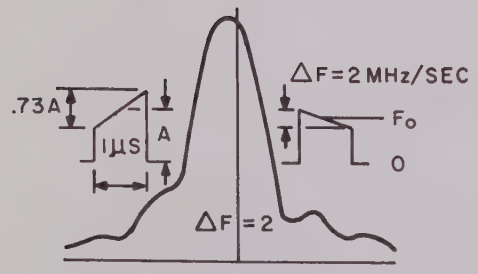
Same pulse spectrum as (b) with more severe FM

C.



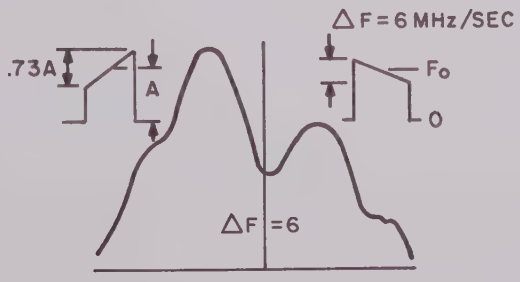
Triangular pulse spectrum without FM during pulse. Effective pulse width is shorter than (a) causing minimas to occur at wider intervals of frequency and lower sidelobe amplitude.

D.



Effect of linear AM and FM during pulse. Observe loss in symmetry due to pulse amplitude slope.

E.



More severe case of FM and AM occurring during pulse.

F.

Figure 2-4. Typical Pulsed RF Display

of the analyzer for the dispersion and sweep rate in use. When spectral lines are to be resolved, a dispersion not exceeding 100 times the prf must be used to enable adequate visual resolution on a 5" CRT. Suitable IF bandwidth and sweep rate settings less than the prf are also required for resolution of the spectral line. For typical prf's and pulse widths, the actual spectral lines of a pulse spectrum are not resolved. In practical rf and microwave pulsed signal analysis the envelope of the signal is of greatest interest.

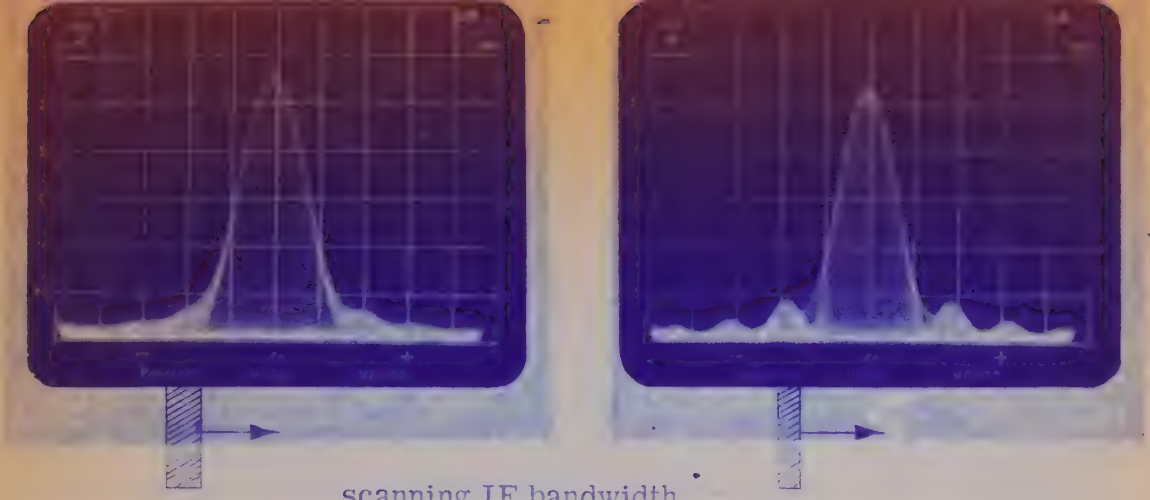
2-29. Figure 2-5 depicts the analysis of several pulsed signals with a variety of signal and analyzer parameters. Accurate pulse spectrum plotting requires adequate selectivity for precise plotting of lobes and nulls. Excessive IF bandwidth smears and degrades the lobe display as illustrated in figure 2-5A. A good empirical compromise between adequate selectivity and the excessive loss of pulse sensitivity due to reduction in bandwidth is an IF bandwidth of one tenth of the pulse width. (See figure 2-5C.)

$$\Delta f_{IF} \leq \frac{0.1}{\tau}$$

Δf_{IF} = analyzer IF bandwidth (Hz)

τ = pulse width (seconds)

$\frac{1}{\tau}$ = one-half main lobe bandwidth or side lobe bandwidth

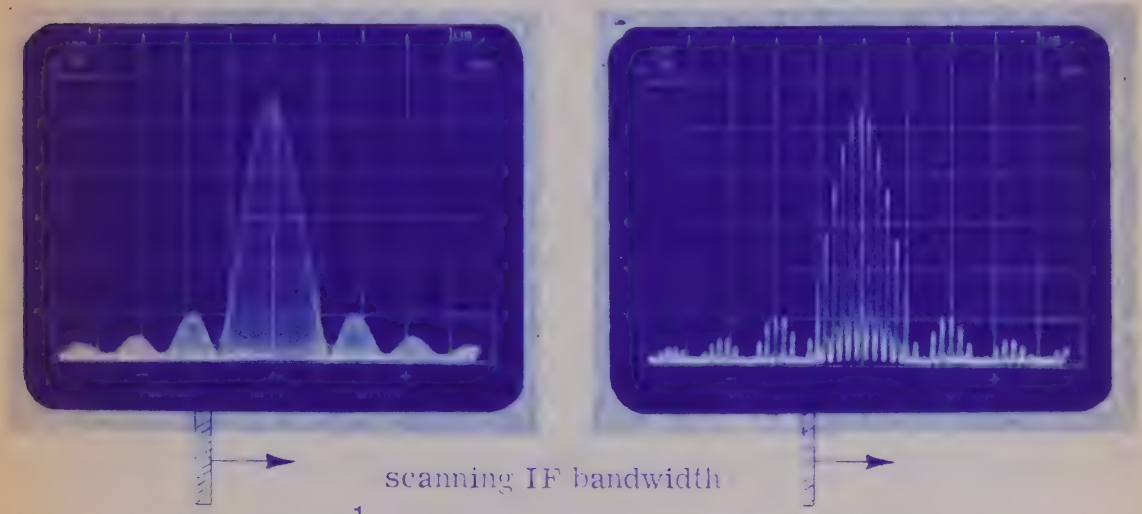


A. $\Delta f_{IF} \approx \frac{1}{\tau}$

Extreme Case: Extremely wide bandwidth yields minimum information.

B. $\Delta f_{IF} \approx 0.5 \frac{1}{\tau}$

Inaccurate Envelope Case: Excessive IF bandwidth fails to resolve lobe null points and distorts envelope.



C. $\Delta f_{IF} \approx 0.1 \frac{1}{\tau}$

Accurate Envelope Case: Moderately narrow bandwidth does not resolve spectral lines but plots spectrum envelope accurately. Moderate prf.

D. $\Delta f_{IF} < f_{prf}$

Spectral Line Case: Very narrow bandwidth resolves spectral lines (within limitations of CRT beam width and visual discrimination). High prf.

Δf_{IF} = analyzer IF bandwidth (cps)

f_{prf} = input pulse repetition rate (cps)

τ = input pulse duration (seconds)

Figure 2-5. Effect Of PRF And Analyzer Bandwidth On Pulsed Signal Analysis

In use, the operator sets the bandwidth as broad as possible consistent with an adequately sharp null definition for the lobes. The sweep rate, in pulsed analysis, is usually set less than one percent of the prf to display at least 100 pulses per scan for adequate sectional representation. With use of external sweep synchronization, a stationary spike pattern is readily obtained. Pulse irregularities and missing pulses can be checked conveniently in this manner as in the testing of magnetrons. Inexperienced users of spectrum analyzers often confuse the spikes due to each pulse with actual spectral lines. A simple test to determine whether spectral lines or pulse spikes are being seen is to observe the effect of changing sweep rate. When the sweep rate is changed and the number of observed vertical deflections remains unchanged, true spectral lines are being observed. (See figure 2-5D.)

2-30. An important factor for measurement of narrow pulsed signals is the analyzer usable sensitivity for pulses. Spectrum analyzers are normally rated and specified for CW sensitivity at minimum IF bandwidths. The relationship between CW and narrow pulse sensitivity is derived in the MIT Radiation Laboratory Series, Volume XI, Chapter 7.

$$e_p = (3/2\ \tau\ \Delta f_{IF})\ e_{cw}$$

e_p = voltage response level to a pulse

e_{cw} = voltage response level to a CW signal at same frequency

τ = rectangular pulse width (seconds)

Δf_{IF} = analyzer IF bandwidth at 3 db points (Hz)

For example, a 0.1 microsecond pulse, and an IF bandwidth of 100 kHz; $e_p = 3/2\ (0.1 \times 10^{-6})\ (100 \times 10^{3})\ e_{cw} = .015\ e_{cw}$ which corresponds to a difference of 36 dB.

The input mixer noise level is increased for narrow pulses compared to the noise level when measuring CW signals at minimum analyzer bandwidth because narrow pulses require wider IF bandwidth ($\simeq \frac{0.1}{\tau}$). The background noise deflection increase is proportional to the ratio of actual bandwidth to minimum bandwidth. For an analyzer with a rated CW sensitivity at 1 kHz IF bandwidth and set at 100 kHz, there would be up to 20 dB additional noise. For the example above, the total sensitivity difference between the deflection due to the 0.1 μsec pulse and a CW signal sensitivity at 1 kc IF bandwidth would be 36 + 35 = 71 dB. At a frequency where the CW sensitivity of the analyzer is -110 dBm and the maximum input level for linear operation is -30 dBm, the maximum usable dynamic range for this pulse signal will be 24 dB. (110 dB - 56 dB = 54 dB). For many applications where the major lobes are of prime interest, the maximum input level can be somewhat greater without significant measurement error. A practical test of adequate freedom from non-linear operation is to check the proportionality of the change in the spectrum display when a small, calibrated amplitude change is introduced. Insertion of 3 dB of attenuation into the input can be used to verify that the instrument is not being overloaded.

2-31. The analyzer's sensitivity for pulsed signals can be determined by subtracting the loss of sensitivity, (See figure 2-6.) from the cw sensitivity at 1 kHz bandwidth.

2-32. NOISE ANALYSIS. In noise analysis (noise being defined as randomly fluctuating signals), the same general techniques are used for setting the

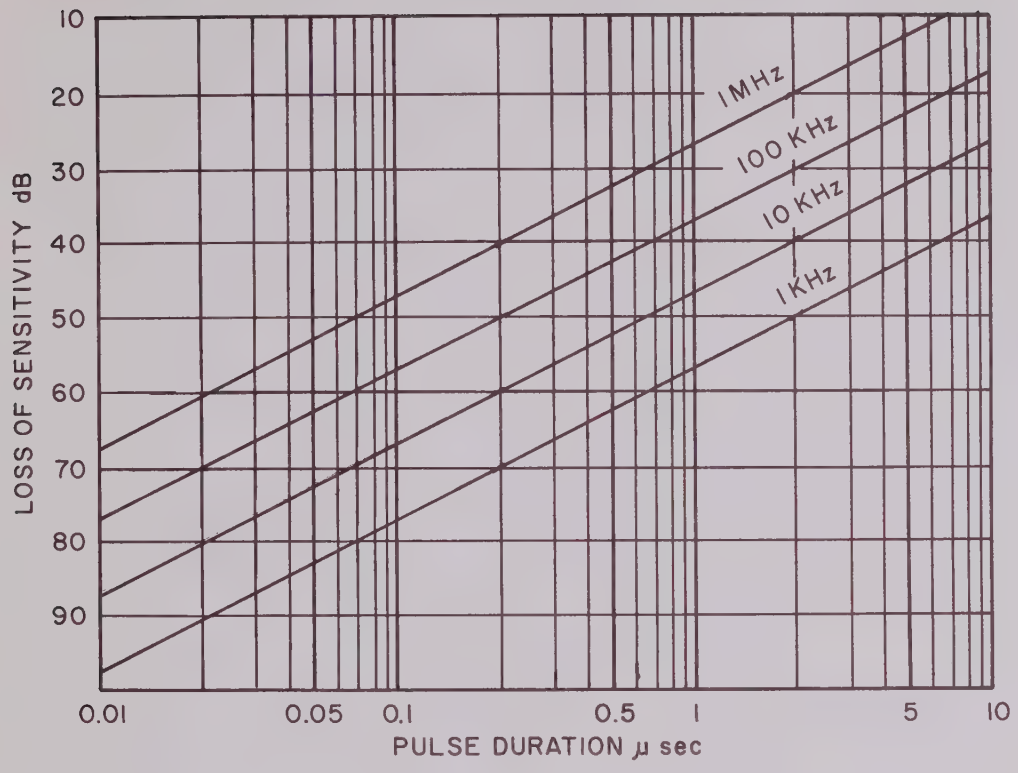


Figure 2-6. Analyzer Sensitivity Correction Due To A Pulsed Signal Compared To A CW Signal at 1 kHz Bandwidth

equipment for the spectrum of interest as are used for discrete signals. If the input spectrum is broadband, it is very important to monitor the input level on the synchroscope to prevent equipment overload. The following special techniques should be noted.

a. In general, a fairly wide IF bandwidth is preferred for noise analysis. This permits relatively rapid scans since a wide IF bandwidth gives better noise envelope averaging than does a narrow IF bandwidth. However, if the noise source is highly selective, an IF bandwidth which is narrow compared to the bandwidth of the resonance is required. This permits presentation of fine detail of the noise characteristics. When a narrow IF bandwidth is used, a low sweep rate is necessary for correct amplitude presentation.

b. The appropriateness of the sweep rate can be determined by changing the sweep rate slightly and noting whether or not there is any change in the envelope amplitude. (The portion of envelope having the greatest slope should be watched since the greatest change will occur here.) The sweep rate should be slow enough so that a small change in sweep rate does not result in an amplitude change. If the sweep rate is at minimum, the frequency dispersion should be reduced and/or the IF bandwidth increased until it is possible to make a small change in sweep rate without changing the amplitude. Once a sweep which is slow enough to provide correct results has been established, a slower sweep can be set if improved envelope averaging is required.

c. In noise analysis, video filtering can be used to obtain averaging of the noise spectrum envelope. It is usually desirable to rotate the BANDWIDTH

VARIABLE control counterclockwise while the BANDWIDTH switch is in the 1, 3, 10, 30 or 100 kHz position, until a single-line presentation is obtained.

d. The equipment sensitivity listed in Section I is applicable only to discrete signals. If absolute noise amplitude measurements are required, a calibration of the spectrum analyzer using a known noise amplitude should be made. Such a calibration must be made at the same scanning velocity (product of sweep width and sweep rate) and IF bandwidth used for measurement since any change in scanning velocity and/or bandwidth changes the amplitude.

2-33. UNDESIRABLE SIGNAL RESPONSES. Because of the broadband design of the analyzer input section, multiple responses may appear on the CRT screen. These responses are described in paragraphs 2-34 through 2-40.

2-34. 160 Megacycle IF Feed-Thru Response in the 0.01 to 1 GHz Band. This signal is easily recognized since the resultant pip will not move across the CRT screen as the TUNING control is varied. Instead, it will remain stationary, behaving like an injected marker signal. It will usually be more than 30 dB below the desired signal. Harmonic or image responses may be generated by this type of signal, but these will be at a lower amplitude than the signal.

2-35. High amplitude Input Signal Response. Application of signals with amplitudes greater than -30 dbm may result in the generation of spurious signals. This -30 dbm limitation applies both to signals displayed on the screen and to signals outside the displayed range. For example, injecting a -10 dbm signal at 100 megacycles may cause harmonics of 100 megacycles to produce a spurious signal pip on the CRT screen at 200, 300, 400 megacycles.

2-36. Spurious IF Amplifier Signal Response. Spurious in-band signals may be generated in the i-f amplifiers if the IF ATTENUATOR control is positioned to allow the signal pip amplitude to greatly exceed a full scale reading.

2-37. Narrow Width, High Amplitude Pulse Response. Very narrow pulse signals (about .01 microseconds) of high amplitude may produce a video pulse in the input mixer. The detected video pulse contains spectral energy which is accepted directly by the 160 megacycle i-f section. Figure 2-7 illustrates the video spectrum of a 0.01 microsecond pulse. Note that all of the second and part of the third lobe falls within the 1st i-f bandwidth of the analyzer and would appear as a stationary display across the full width of the CRT screen.

2-38. Local Oscillator Image And Harmonic Response. The origin and frequency of an unidentified pip can be determined as follows:

a. Set the FREQ DISPERSION switch to 10 MHz/DIV. Note that this produces a full dispersion of 100 MHz.

b. Adjust the TUNING control to place the signal pip at the far right vertical screen calibration. Note the frequency indicated by the tuning dial pointer. (Read from the .94 - 3.5 range even though the RANGE switch might be set for another range; the SIGNAL FREQUENCY dial indicates the input frequencies that utilize the local oscillator fundamental.)

c. Adjust the TUNING control to place the signal pip at the far left vertical screen calibration. Note the frequency indicated by the SIGNAL FREQUENCY dial. Calculate the difference between the frequencies obtained in steps b and c.

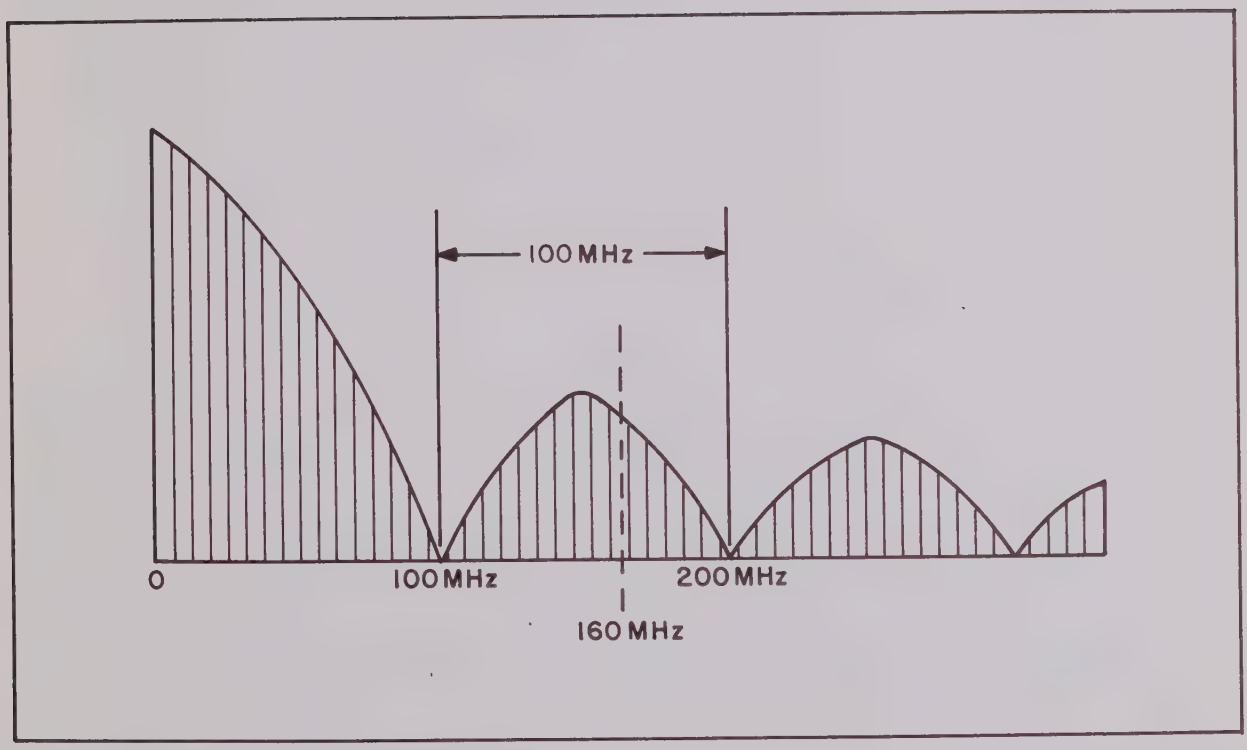


Figure 2-7. Spectrum Of 0.01 Microsecond Pulse

d. Calculate the order of the local oscillator harmonic producing the signal pip using equation (1) below:

$$(1)\quad n = \frac{\text{dispersion}}{f_{diff}} \qquad n = 1,\ 2,\ 3\ \ldots$$

Where n = order of harmonic of local oscillator producing pip.

f_{diff} = difference in frequency between SIGNAL FREQUENCY dial settings.

NOTE

When rounding off "n," note that only the 1, 3, 5, 7, and 11 harmonics are used. Round off n to one of these integers.

e. Check whether the pip is a "non-image" or "image" type pip by comparing the direction of pip travel with respect to the direction of travel of the SIGNAL FREQUENCY dial. If the pip moves from right to left as the dial reading increases in frequency, the pip is a "non-image" type. If the pip moves from left to right as the dial increases in frequency, the pip is an image.

f. If the pip is a "non-image" type, calculate the frequency of the signal using equation (2) below:

$$(2)\quad f_x = nf_{dial} + (n-1)\,160$$

Where: f_x = frequency of the unknown signal in MHz; f_{dial} = tuning dial reading when signal being investigated is at the center of CRT screen (f_{dial} read on fundamental band); n = order of harmonic of local oscillator producing pip.

g. If the pip is an "image" type, calculate the frequency of the signal using equation (3) below:

$$(3)\quad f_x = nf_{dial} + (n+1)160$$

h. Turn the TUNING control to the calculated signal frequency. The signal pip should appear on the CRT screen. Recheck that the pip is a "non-image" type; repeat steps b, c, and d, reading the proper range on the SIGNAL FREQUENCY dial (in accordance with RANGE switch setting), and noting that n now equals 1 and that the pip moves to the left when the TUNING control is rotated clockwise.

Note 1

Errors can occur in the foregoing method because of the rounding off of "n" when "n" is a large number (5 or above). If a signal pip does not appear at the calculated place, or if a pip with an incorrect value of "n" appears, repeat and recheck the foregoing procedures. Also try the next lower and next higher permissible value of "n".

Note 2

To determine the frequency of an unknown signal, adjust the TUNING control to move the unknown signal across the screen and note the upper and lower frequency limits indicated by the SIGNAL

FREQUENCY dial. If the difference between the observed frequencies is approximately equal to the dispersion, the frequency of the signal will be indicated by the SIGNAL FREQUENCY dial when the signal is centered on the screen. If the frequency difference is some multiple or submultiple of the dispersion, you are on the wrong RANGE band.

2-39. First Mixer Signal Harmonic Response. If it has been determined that the pip on the screen is not caused by the fundamental (or correct harmonic) of the local oscillator, it is possible that the pip is some harmonic of the signal. This harmonic can be caused by the input signal overloading the input mixer, or it can be a true component of the input signal. In either case, the fundamental signal can be found by tuning to the various sub-harmonics (1/2, 1/3, 1/4, etc.) of the dial frequency and searching for signals.

2-40. If it is necessary to determine the source of the harmonic, either of the following procedures can be tried:

a. Insert a known amount of attenuation between the signal source and the analyzer. Use an attenuator which operates in the frequency of both the fundamental and the harmonic. If the harmonic amplitude decreases the same as the fundamental, then the harmonic is a signal component. If the harmonic decreases at a much greater amount than the fundamental, the harmonic is produced in the input mixer of the analyzer.

b. Insert a high pass filter between the signal source and the analyzer. This would eliminate the fundamental but have a negligible effect on the harmonic. Therefore, if the harmonic is not eliminated, it is a signal component; if the harmonic is eliminated, it is created in the input mixer.

2-41. SIGNAL MEASUREMENTS.

2-42. AMPLITUDE MEASUREMENT OF DISCRETE SIGNALS. The most accurate method of measuring relative signal strengths that are less than 20 dB apart is to use the linear amplitude presentation on the CRT. When it is necessary to measure two or more signals of widely differing amplitudes (greater than 20 dB but less than 60 dB), the logarithmic presentation should be viewed on the CRT.

a. Examine the complete spectrum with the AMPLITUDE SCALE switch set to LOG and IF ATTENUATOR switch set to 00 DB. No inputs should exceed -30 dbm.

NOTE

Failure to limit the input signal to -30 dbm could result in incorrect amplitude readings and indications of frequency components that are not present in the input.

b. Examine the signals of interest in narrower dispersions.

NOTE

Signal levels too low to be analyzed in terms of the sensitivity of the equipment can be examined by amplifying them by means of a preamplifier of low noise and distortion, and known gain. The output of the preamplifier must then be considered the signal being analyzed.

c. To measure signals of comparable amplitude (0 - 20 dB difference), set the AMPLITUDE SCALE switch to LIN. For greater differences, set the switch to LOG. For very small differences, set the switch to PWR; in this switch position, small amplitude differences are exaggerated, with the relative power rather than relative amplitude being displayed. The relative heights of the pip deflections are accurate within the limits of flatness of response of the spectrum analyzer. Better accuracy of amplitude ratio measurement is provided in the LIN position of the AMPLITUDE SCALE switch than in the LOG or PWR position. The LIN/PWR scale, which is on the right side of the graticule, is divided into five divisions, numbered from .2 to 1.0. The LOG scale, at the left side of the graticule, is calibrated from 0 dB to -60 dB in 10-dB increments. (Note: Full scale LOG does not correspond to full scale LIN.)

2-43. FREQUENCY MEASUREMENT OF DISCRETE SIGNALS.

a. Repeat steps a and b of paragraph 2-42.

b. Set the MARKER MODULATION switch to OFF and adjust the LEVEL control for relatively low level markers. Adjust the SIGNAL FREQ POSITION control until the marker is carefully superimposed on the center graticule line.

c. Adjust the attenuators for a reasonably large signal pip. Set the AMPLITUDE SCALE switch to LIN because the pips are sharper in LIN than in LOG.

d. Adjust the TUNING control until the signal is centered on the marker. Read the frequency from the SIGNAL FREQUENCY dial.

e. Estimate the frequency of a pip that is not at the center by adding (if the pip is to the right) or subtracting (if the pip is to the left) the displacement in kHz or MHz from the center frequency reading. The displacement is determined by multiplying the number of horizontal divisions from fo by FREQ DISPERSION switch setting; be sure the FREQ DISPERSION VARIABLE control is fully cw (CAL). For example, if the SIGNAL FREQUENCY dial reads 10.60 GHz, the FREQ DISPERSION switch is set at 10 MHz/DIV, and the pip appears 2-1/2 divisions to the left of the center graticule line, the signal frequency would be estimated to be 10,600 - 25 = 10,575 MHz.

2-44. AM MEASUREMENTS. The amplitude-versus-frequency display of the analyzer is useful in determining the spectrum of signals contained in the amplitude-modulated signal being observed. To determine the percentage modulation, connect an oscilloscope to the 60 MHz output jack; the amplitude-versus-time display provides the most direct means for making this measurement.

2-45. FM MEASUREMENTS. The deviation and modulation index can be deduced readily from the relative levels of the carrier and sidebands using the Bessel function coefficients of the series expansion for an FM signal (See Panoramic Analyzer Volume 1, #4 for FM measurement techniques). FM

deviations of transmitters and signal generators are frequently measured by varying the modulation frequency until the carrier level is at the first null. The FM deviation is obtained by multiplying that modulating frequency by 2.4. This is the most accurate practical method of measuring FM deviations and actual band occupancy of the sidebands. An advantage of this dynamic analysis is the immediate revelation of second order effects such as residual AM on the FM which causes assymmetry of the sidebands. To measure the FM deviation of an FM signal generator or transmitter, follow the procedure given below:

a. Couple the spectrum analyzer to the FM signal generator or transmitter by cable or suitable antenna or other pickup devices.

b. With no modulation input, center the carrier on a spectrum analyzer using the TUNING control.

c. Connect a signal generator to provide the modulation input; set the signal generator to a suitable frequency within the input range of the FM signal generator or transmitter, and set the amplitude of the modulating signal generator to 0. The modulation frequency must be greater than the bandwidth of the analyzer.

d. Slowly increase the amplitude of the modulating signal generator until the carrier pulse decreases to 0 on the spectrum analyzer display. Decrease the IF ATTENUATOR setting and increase the IF GAIN setting to provide the maximum sensitivity for observing the carrier pulse null. When the carrier first reaches 0, the modulation index is 2.4 and the deviation is 2.4 times the frequency of the modulating source. Using Bessel tables, higher carrier nulls or sideband nulls may be used.

2-46. PULSE MEASUREMENTS. The characteristics of pulsed rf signals can be inferred and the pulse width measured from the amplitude-versus-frequency display. (Refer to paragraph 2-27.) Many of these characteristics can be checked by converting the analyzer to a synchroscope and setting the SWEEP/SYNC switch to the INT SYNC (red) position. The pulse width, incidental AM, and pulse repetition rate can be measured directly on the synchroscope display (refer to paragraph 2-53), thus simplifying the procedure of making these measurements.

2-47. APPLICATIONS.

2-48. GENERAL. Spectrum Analyzer Model SPA-100 can be profitably employed to reduce the time required to take measurements and make adjustments at industrial production facilities as well as in the field. The applications described below are not intended to include all analyzer applications; rather they have been selected to suggest the numerous ways in which spectrum analyzers can be helpful. The description of each application is intentionally made brief; additional information on a specific user application can be obtained by telephoning the Marketing Department, Singer Co. Metrics Division, Bridgeport, Conn.

2-49. TUNING PROCEDURES. The amplitude-versus-frequency display of the spectrum analyzer makes it a very useful tool for adjusting equipment that requires specific frequency response characteristics.

a. IF strips, low-pass, high-pass, and band-pass filters, and traps can be adjusted by applying a swept oscillator or impulse generator to the input of the

circuit and observing the output on the spectrum analyzer. The circuits can then be adjusted for the desired frequency response.

b. Varactor multipliers can be tuned to the desired harmonics of their input oscillators by observing the outputs at various points along the varactor multiplier chain to guarantee that the multipliers are not inadvertently tuned to the incorrect harmonic. Filters at the output of the chain can be adjusted to remove undesired outputs that would be clearly shown on the analyzer display.

2-50. CHECKS OF RADAR SET PERFORMANCE. The spectrum analyzer may be connected to a directional coupler of the radar set (taking care not to exceed the -30 dbm input limitation of the analyzer) or coupled to the radar set by a suitable antenna.

a. The radar output pulse can be observed on the spectrum analyzer to determine pulse width, prf, incidental AM and FM, mode failures, and relative sideband amplitudes and symmetry.

b. The energy distribtuion in the transmitted pulse can be determined and used as the basis for the receiver bandwidth design. If the receiver bandwidth is too narrow, the pulse shape will not be preserved and the radar accuracy will be compromised. On the other hand, increasing the bandwidth beyond the point that includes virtually all of the transmitted energy serves no useful purpose, and will decrease the signal-to-noise ratio.

c. The standing wave ratio can be determined with the analyzer used as an rf voltmeter. By connecting the analyzer to a slotted line detector in the radar set, the maximum and minimum voltages along the slotted line can be determined; thus, the standing wave ratio can be calculated.

d. Receiver afc can be checked by displaying both the magnetron frequency and the local oscillator frequency simultaneously. Because the magnetron is pulsed, a typical pulsed rf pattern will represent the magnetron frequency, while the local oscillator frequency will appear as a single pip displaced by the IF frequency from the center of the magnetron pattern. Any magnetron pulling resulting from antenna rotation should produce corresponding shifts in the local oscillator frequency.

e. A TR box may be tuned accurately to the magnetron frequency by first tuning the spectrum analyzer so that the magnetron frequency is precisely centered on the display. Then with the magnetron turned off and an impulse generator applied to the TR box, the spectrum analyzer can display the frequency response characteristics of the TR box, and the TR box can be tuned so that its center frequency is the same as the magnetron frequency.

2-51. OBTAINING ANTENNA PATTERNS. An X-Y plot of an antenna pattern can be obtained by using the spectrum analyzer as an rf voltmeter and by having the analyzer sweep synchronized to the antenna rotation.

a. Connect the spectrum analyzer input to the antenna under test. Install the antenna on a rotating platform and with the antenna directed at a remote transmitter, tune the spectrum analyzer to the transmitted frequency.

b. Set the SWEEP/SYNC switch to SINGLE and the FREQUENCY DISPERSION switch to 0. Set the AMPLITUDE SCALE switch to LOG and adjust the IF ATTENUATOR switch and IF GAIN until the amplitude of the display is 0 dB. Set the SWEEP switch to 1000 MS/DIV.

c. Rotate the antenna at a speed slightly faster than one revolution per second so that a complete revolution will be completed within the time of one sweep of the analyzer. When the antenna is directed away from the transmitter during its rotation, press the SINGLE pushbutton on the analyzer. In this way, the main lobe of the antenna pattern will appear approximately centered on the analyzer display and on the X-Y recording.

2-52. RFI MEASUREMENTS. Spectrum analyzers are extremely useful when used in conjunction with RFI meters to help locate and identify the nature of the signal measured on the RFI meter. Except for approximate measurements, a spectrum analyzer cannot replace an RFI meter because the design of the RFI meter and its accurate calibrations are specifically made for this type of measurements. On the other hand, the very narrow window of an RFI meter makes it impractical for locating signals (scanning), and the meter indications of an RFI meter are not as conclusive as a spectrum analyzer display for the identification of the signals being measured.

2-53. SYNCHROSCOPE OPERATION.

2-54. The built-in synchroscope circuits in the Main Frame make it simple to examine a signal that was observed on the amplitude-versus-frequency display on an amplitude-versus-time display. The transition to a synchroscope eliminates sweeping of the local oscillator frequency so that scanning of the frequency window ceases; only the signal appearing at the center of the frequency display is presented on the synchroscope display. This signal is detected

in the Main Frame and the video (modulation envelope) can be viewed on the CRT. The widest IF bandwidth of 1000 kHz should be used so that all frequency components of the signal are passed, resulting in an undistorted display. The synchroscope sweep may be triggered by an external signal or by the detected video. Figure 2-8 compares several frequency-base displays with their equivalent time-base displays.

2-55. Follow the procedure given below to use the Analyzer as a synchroscope:

a. When the desired signal is centered about the center marker, set the FREQ DISPERSION switch to 0. Adjust the SIGNAL FREQ POSITION controls for the maximum amplitude of the signal on the CRT.

b. Set the SWEEP switch to any of the US/DIV positions (red positions).

c. Set the SWEEP/SYNC switch to EXT for external sync (connect the external sync input at J1-D) or to INT for internal sync.

d. Set the MARKER MODULATION switch to OFF.

e. Set the BANDWIDTH switch to 1000 kHz.

f. Set the AMPLITUDE SCALE switch to LIN for a linear amplitude display.

g. Adjust the amplitude of the waveform by using the IF ATTENUATOR switch.

NOTE

Do not adjust the tuning of the tuning head or the SIGNAL FREQ POSITION controls while in synchroscope operation. Tuning will cause distortion or loss of signal.

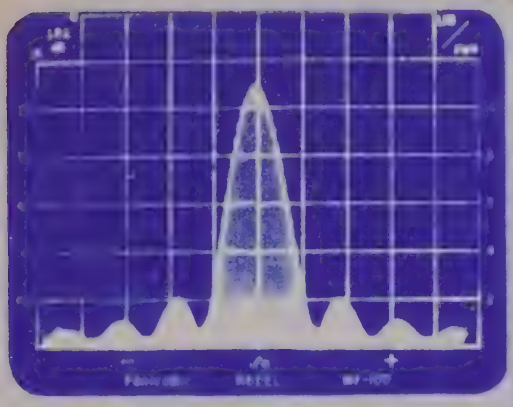
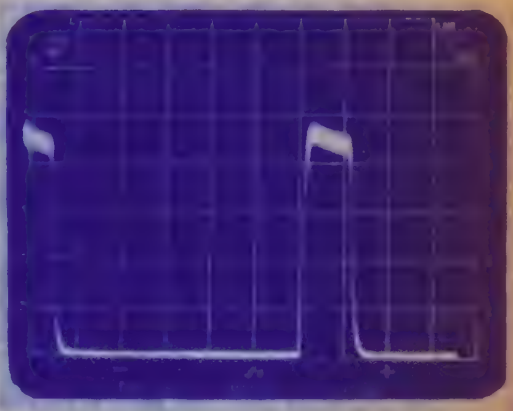
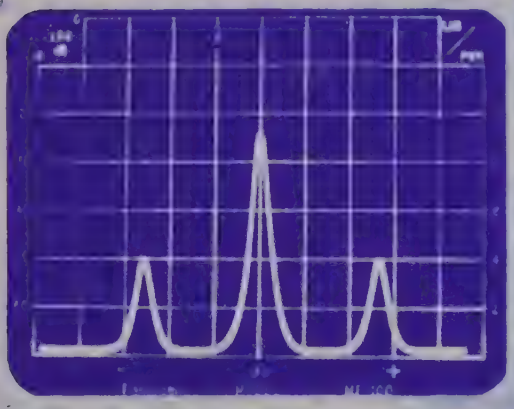
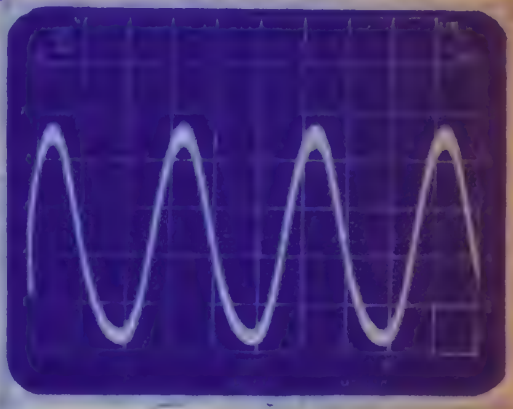
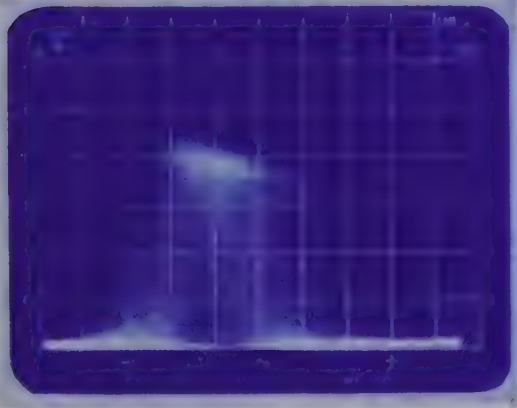
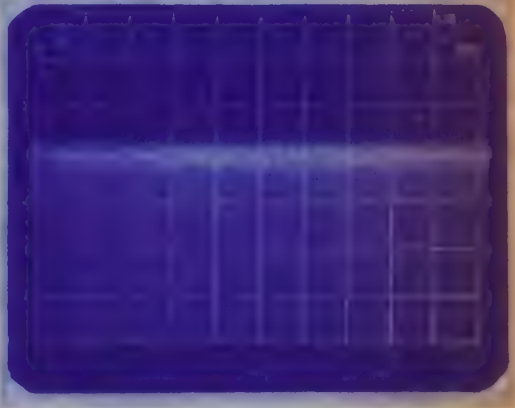
SIGNAL	FREQUENCY-BASE DISPLAY	TIME-BASE DISPLAY
Pulse		
Single Tone Amplitude Modulation		
Noise		

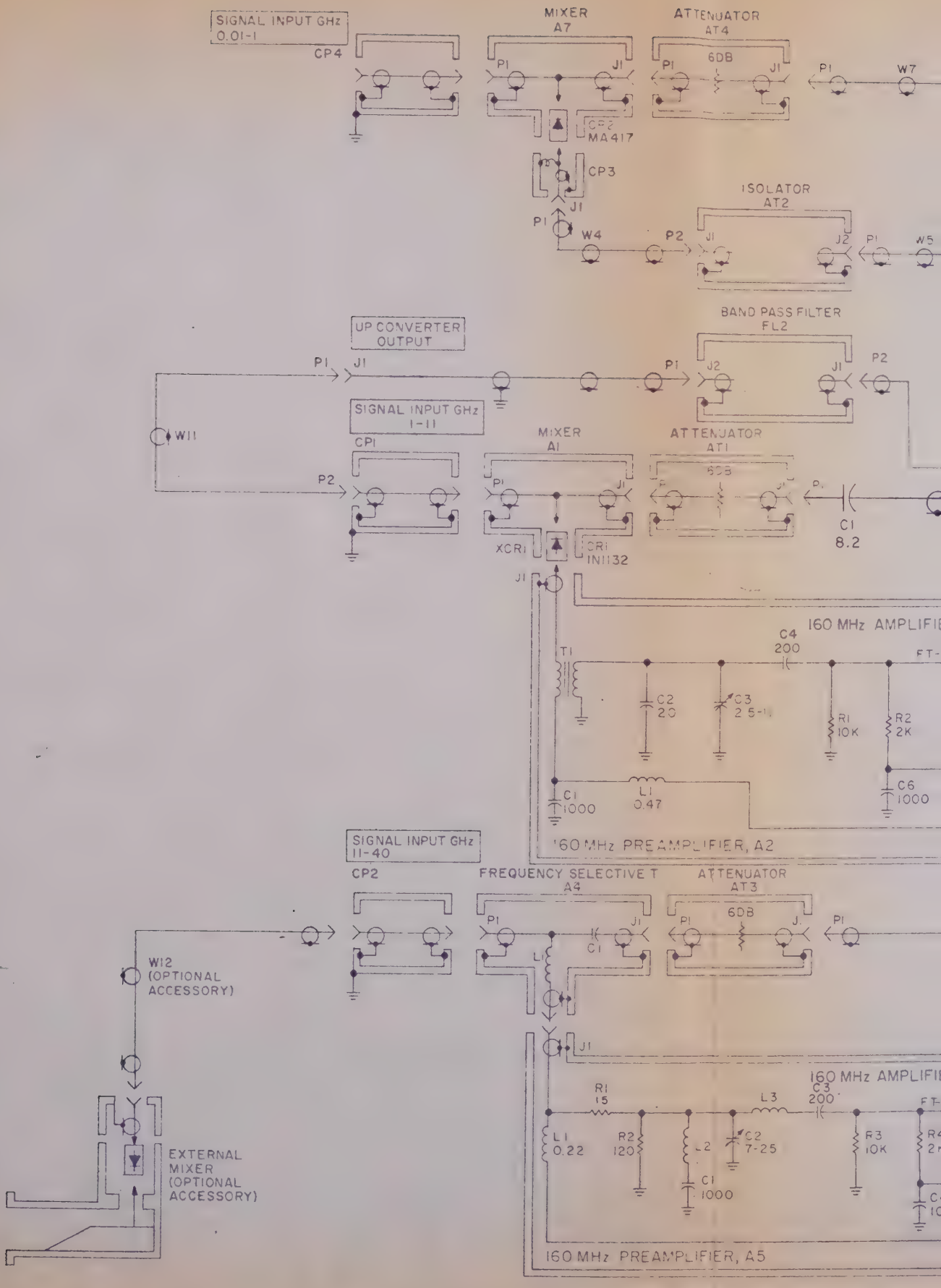
Figure 2-8. Comparison of Frequency-base And Time-base Displays

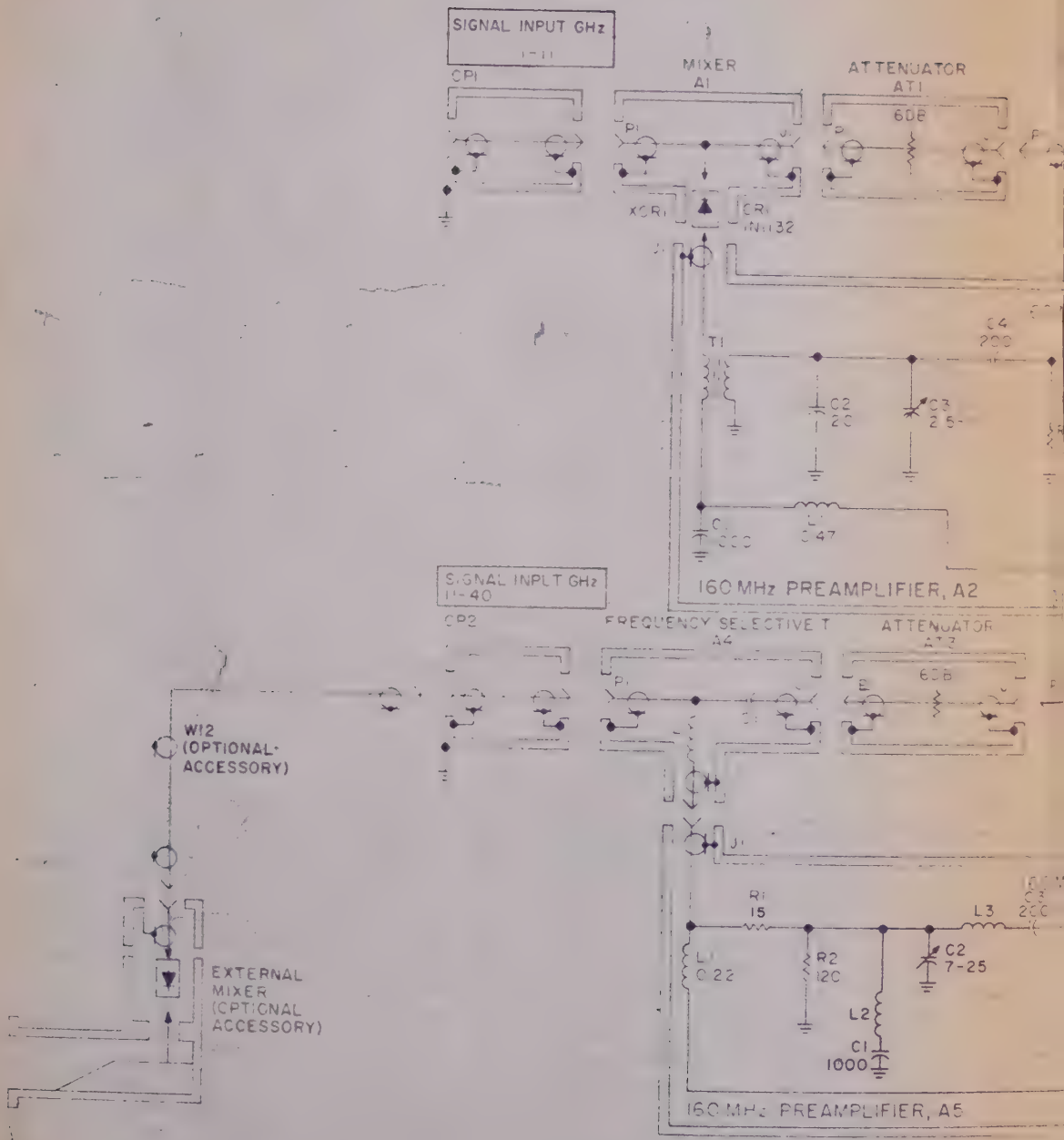
2-56. PACKAGING.

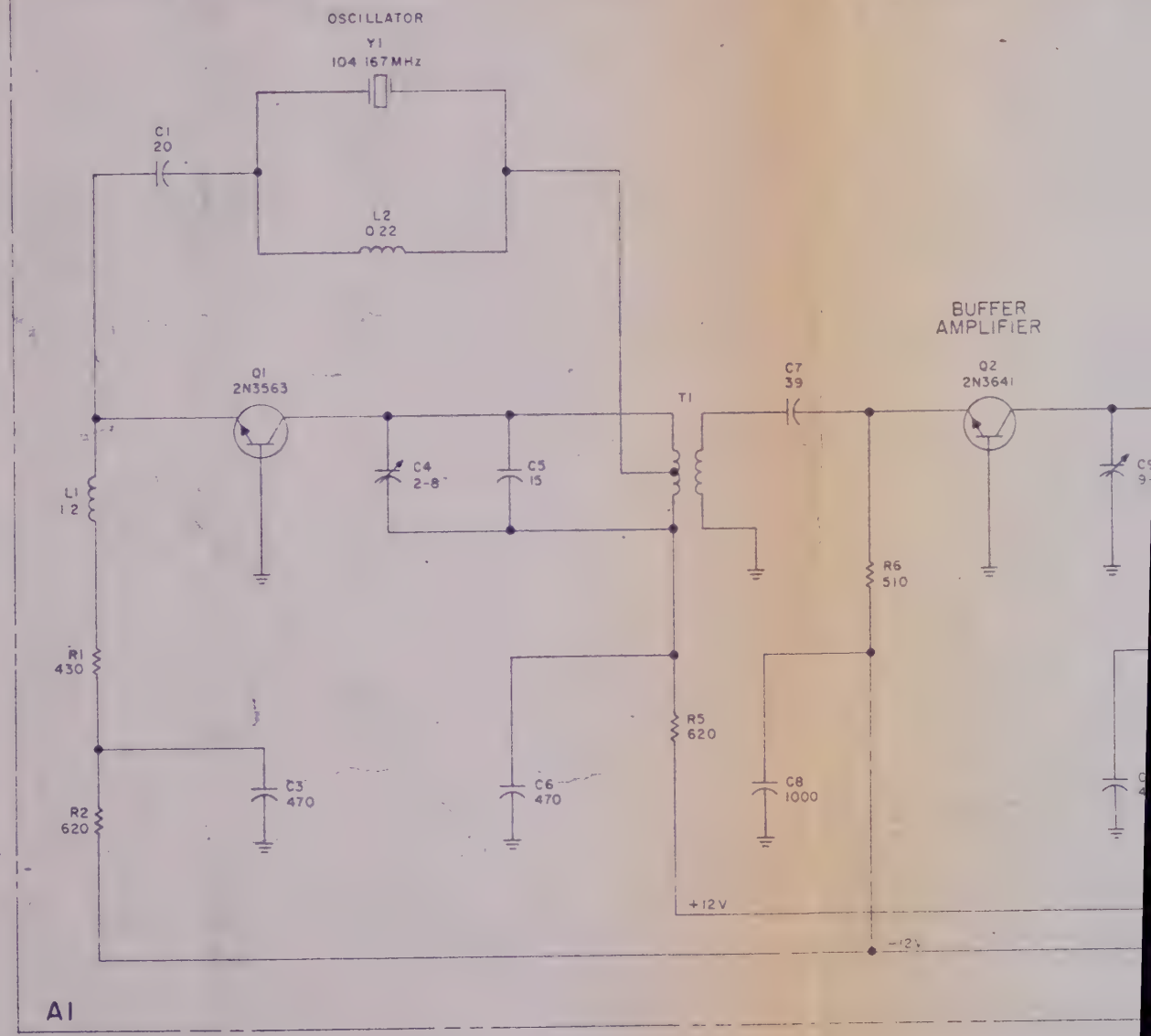
2-57. Figure 2-9 illustrates the method of packaging the Analyzer for shipment or long term storage. For short term storage use a suitable covering such as a sheet of paper or plastic, and store the instrument in a clean dry area. Store accessories and instruction manual in a carton or bag and fasten it to the equipment to avoid loss.

(To Be Supplied)

Figure 2-9. Packaging Diagram


SIGNAL INPUT GHz
0.01-1
CP4
MIXER
A7
P1
J1
CR2
MA417
ATTENUATOR
AT4
6DB
W7
CP3
ISOLATOR
AT2
W4
P2
J2
W5
BAND PASS FILTER
FL2
UP CONVERTER
OUTPUT
SIGNAL INPUT GHz
1-11
W11
CP1
MIXER
A1
ATTENUATOR
AT1
XCR1
CR1
IN1132
C1
8.2
160 MHz AMPLIFIE
C4
200
T1
C2
20
C3
2.5-11
R1
10K
R2
2K
C6
1000
L1
0.47
160 MHz PREAMPLIFIER, A2
SIGNAL INPUT GHz
11-40
CP2
FREQUENCY SELECTIVE T
A4
ATTENUATOR
AT3
W12
(OPTIONAL
ACCESSORY)
EXTERNAL
MIXER
(OPTIONAL
ACCESSORY)
160 MHz AMPLIFI
R1
15
C3
200
L3
L1
0.22
R2
120
L2
C2
7-25
R3
10K
C1
1000
160 MHz PREAMPLIFIER, A5


SIGNAL INPUT GHz
MIXER
A1
ATTENUATOR
AT1
60B
CP1
P1
J1
XCR1
CR1
1N132
T1
C4
200
C2
20
C3
2.5-
C5
.000
L1
.047
160 MHz PREAMPLIFIER, A2
SIGNAL INPUT GHz
CP2
FREQUENCY SELECTIVE T
A4
ATTENUATOR
AT3
60B
P1
J1
W12
(OPTIONAL
ACCESSORY)
EXTERNAL
MIXER
(OPTIONAL
ACCESSORY)
R1
15
L3
C3
200
L1
0.22
R2
120
C2
7-25
L2
C1
1000
160 MHz PREAMPLIFIER, A5



NOTES UNLESS OTHER
1. ALL RESISTOR
2. ALL CAPACIT
3. ALL INDUCTO

INSTRUCTION MANUAL

Panoramic*

MAIN FRAME

MODEL MF-100

SINGER
INSTRUMENTATION

Precision electrical and electronic instruments for measurement

emc — EMPIRE* — Gertsch* — Panoramic* — Sensitive Research*

THE SINGER COMPANY • METRICS DIVISION

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*Interconnection Diagram followed by Assemblies A1, A2, A2A1, etc.

SECTION I

INTRODUCTION

1-1. SCOPE OF MANUAL.

1-2. This manual provides operating and maintenance instructions on Model MF-100 Main Frame (figure 1-1), manufactured by the Singer Company, Metrics Division, Bridgeport, Connecticut. This frame when used in conjunction with tuning heads such as Model RF-100, RF-100A, RF-3000 or others to be announced, form a complete, self-contained spectrum analyzer. When Model MF-100 Main Frame is used with any of the above mentioned tuning heads, the combination is designated PANORAMIC* Microwave Spectrum Analyzer Model SPA-100, SPA-100A, SPA-3000, etc. Although the purpose of this manual is only to provide coverage on the Main Frame, the description assumes that it is operating with a tuning head. Thus, reference to displays produced on the CRT of the spectrum analyzer assumes a thorough practical knowledge of the tuning head functions. Coverage similar to that presented herein on the Main Frame is provided in an instruction manual associated with the various tuning heads.

1-3. The information contained in this manual refers to the standard version of the Main Frame and is current only to the date of publication. Differences in equipment, components, specifications, and performance resulting from engineering improvements or special customer requirements are described in applicable addendum or difference data sheets.

1-4. PURPOSE AND USE OF THE EQUIPMENT.

1-5. Model MF-100 Main Frame, when operating with an appropriate tuning head, provides a means for displaying the amplitude versus frequency plot for input signals within the frequency range of the tuning head. The displays appear on a medium short persistence CRT with a calibrated overlay

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(To be supplied)

Figure 1-1. Model MF-100 Main Frame and Accessories

graticule. (See figure 1-2.) The MF-100 display can be converted from a frequency base to a time base merely by operating a few front panel controls. Thus, an auxiliary oscilloscope is no longer needed to observe the modulation (amplitude vs time) of the rf signal to which the analyzer is tuned.

1-6. The portable Main Frame operates on a-c line voltage (115 or 230 volts 47-440 Hz).

1-7. Publications which accompany individual tuning heads describe the integrated operation and particular applications for the Main Frame when used with associated tuning heads. As a result, discussion on the use of the Main Frame is referred to the manual of the tuning head with which it is being used.

1-8. GENERAL DESCRIPTION.

1-9. Each Main Frame contains i-f and video amplifiers, deflection circuits and power supplies. In addition to providing operating voltages for the deflection circuits and CRT, the power supplies also furnish the operating voltages for the particular tuning head selected for use.

1-10. Model MF-100 Main Frame may be used virtually anywhere; in laboratories, production lines, on location in the field, aboard ships, aircraft and other conveyances. The system enables time saving graphic swept band signal analysis to be made in areas where portability requirements formerly required the use of tedious point-by-point techniques.

1-12. Solid-state design results in extraordinary display stability in addition to miniaturization. Narrow band scans are precisely repeatable, even in rugged field environments or after moving and handling. Since the circuits are completely transistorized, there is virtually no warm-up time after turn-on.

1-13. The aluminized CRT used provides a bright, sharply focused display for convenient viewing. The 5-inch, round CRT tube used for display is equipped with a standard camera mount bezel, facilitating the use of Model GA-200 or SM-200 Polaroid Oscilloscope Camera.

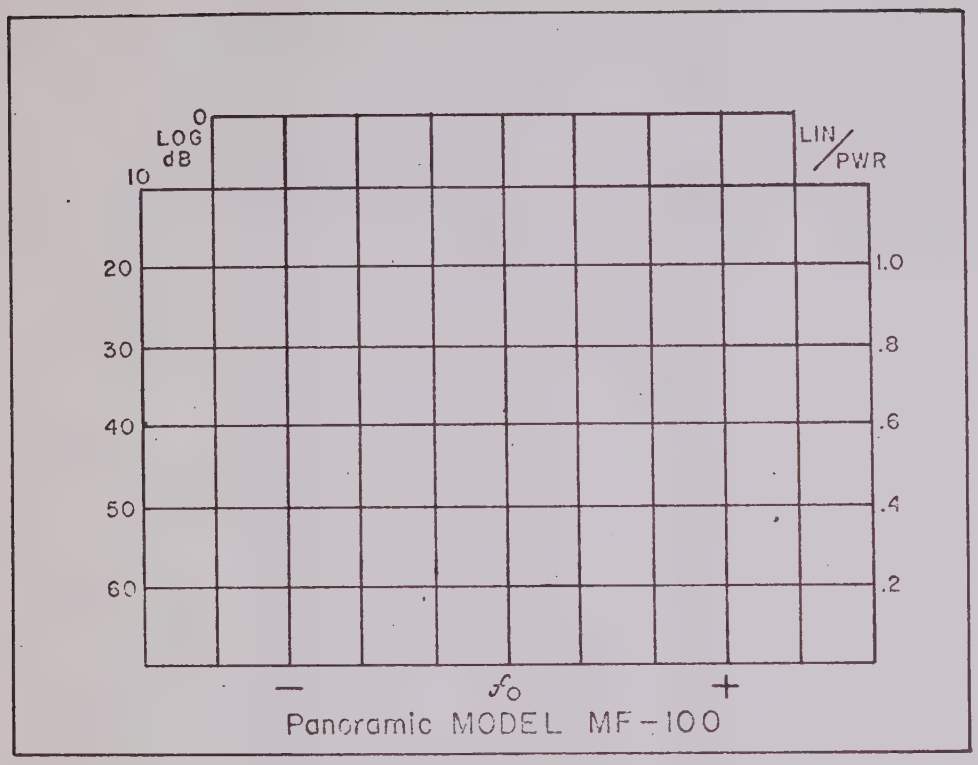


Figure 1-2. CRT Display Scales

1-14. The Model MF-100 Main Frame is designed to be mounted in a standard 19-inch rack or on a bench.

1-15. MF-100 SYSTEM COMPONENTS.

1-16. The majority of the components of the Main Frame are mounted on printed circuits cards. There are several accessory items supplied with the MF-100. These items are illustrated in figures 1-1 and listed in table 1-1.

1-17. SPECIFICATIONS.

1-18. Specifications for the Spectrum Analyzer depend upon the tuning head that operates with the MF-100. They are listed, therefore, in the manual for the particular tuning head.

1-19. ELECTRON TUBE, TRANSISTOR, CRYSTAL DIODE, AND FUSE COMPLEMENT.

1-20. Table 1-2 lists all transistors, and crystal diodes used in the Main Frame and table 1-3 lists the fuse complement. The CRT (V1), a 5ADP3/A, is the only electron tube in the Main Frame.

TABLE 1-1. ACCESSORY ITEMS SUPPLIED

Note

Accessories applicable to specific tuning heads are described in the tuning head manual.

Figure 1-1 Index No.	Description	Part No.	Use
1	Rack Mount Ears Assembly RM-100	102-0106-001	Consists of two angle brackets and mounting hardware to permit rack-mounting the MF-100.
2	Rack Mount Ears and Slide Assembly RM-101	102-0107-001	Consists of one RM-100, a pair of slides and spacer plates and mounting hardware to rack-mount the MF-100.

TABLE 1-2. MAIN FRAME TRANSISTOR AND CRYSTAL DIODE COMPLEMENT

Location	Ref. Desig.	Type	Function
Main Chassis	CR1	1N821	Limiting
	Q1	2N3613	+12V series regulator
	Q2	2N3613	Dc amplifier
	Q3	2N3613	Dc amplifier
	Q4	2N3613	-12V series regulator
	Q5	MJ2252	+100V series regulator
Marker Oscillator A2A1	CR1-CR4	1N34A	Balanced mixer
	Q1	2N3563	160MHz oscillator
	Q2	2N3563	Amplifier
	Q3	2N3565	10 MHz oscillator
	Q4	2N3565	1 MHz oscillator
Marker Level A2A2	CR1, CR2	FDH666	Attenuator
160 MHz W. B. Amplifier A2A3	Q1	SE3002	Amplifier
	Q2, Q3	2N3563	Amplifiers
	Q4	2N3563	Emitter follower
Narrow Band and Wideband Swept Oscillator A2A7	CR1-CR4	1N82AG	Balanced mixer
	CR5	FDH666	Clamp
	CR6	1N942A	Zener regulator
	Q1	2N3642	Adder
	Q2	40256	Shaping amplifier
	Q3	2N3563	W. B. swept oscillator
	Q4	2N3932	IF amplifier
	Q5	2N3563	N. B. swept oscillator
	Q6	SE7010	Shaping amplifier
	Q7	2N3642	Adder

TABLE 1-2. MAIN FRAME TRANSISTOR AND CRYSTAL DIODE COMPLEMENT (Cont)

Location	Ref. Desig.	Type	Function
60 MHz IF Amplifier A2A8	Q1, Q2	2N3563	60 MHz amplifiers
	Q3	SE5001	60 MHz amplifier
	Q4	2N3563	60 MHz amplifier
60-6.5 MHz Converter A2A9	Q1	2N3563	53.5 MHz oscillator
	Q2	2N3563	Mixer
6.5 MHz WB Filter A3A1	CR1-CR4	1N251	Switch
	Q1	2N3563	6.5 MHz amplifier
6.5 MHz NB Filter A3A2	Q1	2N3694	6.5 MHz amplifier
	Q2	2N3694	Emitter follower
Variable Bandwidth A3A3	CR1-CR4	1N251	Switch
	Q1	2N3694	6.5 MHz amplifier
	Q2	2N3015	Emitter follower
	Q3	2N3015	Paraphase amplifier
	Q4	2N3694	Emitter follower
	Q5	2N3694	6.5 MHz amplifier
	Q6	2N3694	Paraphase amplifier
	Q7, Q8	2N3694, 2N3642	Darlington emitter follower
Log Amplifier A3A4	CR1-CR6	1N251	Detectors
	Q1	SE3002	6.5 MHz limiter amplifier
	Q2, Q3	2N3646	6.5 MHz limiter amplifiers
	Q4	2N3694	Emitter follower
	Q5-Q7	2N3646	6.5 MHz limiter amplifiers
Lin-Power Scale A3A5	CR1	FDH666	Detector
	CR2	1N749	Voltage dropping coupling

TABLE 1-2. MAIN FRAME TRANSISTOR AND CRYSTAL DIODE COMPLEMENT (Cont)

Location	Ref. Desig.	Type	Function
A3A5 (Cont)	Q1	2N3641	6.5 MHz amplifier
	Q2	2N3568	Emitter follower
	Q3, Q4	2N3638	Emitter followers
	Q5	U148	Square law amplifier
	Q6	2N3568	Emitter follower
	Q7	2N3638	Emitter follower
Deflection Amplifier A4	Q1, Q2	2N3694	Difference amplifier
	Q3	2N3638	Amplifier
	Q4, Q5	2N3694	Difference amplifier
	Q6	2N3638	Amplifier
	Q7	2N3641	Constant current source
	Q8, Q9	2N3440	Difference amplifier
	Q10	2N3641	Constant current source
	Q11, Q12	2N3440	Difference amplifier
Sawtooth Intensifier A5	CR1	FDH666	Clamp
	CR2	FDH666	Clamp
	CR3	FDH666	Switch
	CR4	1N749	Zener regulator
	Q1	- - -	Not used
	Q2, Q3	2N3694, 2N3641	Difference amplifier
	Q4, Q5	2N3646	Schmitt trigger
	Q6	2N3638	Pulse amplifier
	Q7, Q8	2N3641, 2N3440	Difference amplifier

TABLE 1-2. MAIN FRAME TRANSISTOR AND CRYSTAL DIODE COMPLEMENT (Cont)

Location	Ref. Desig.	Type	Function
A5 (Cont)	Q9	2N3440	Driver emitter follower
	Q10	2N3646	Emitter follower
	Q11, Q12	2N3646	Bistable multivibrator
	Q13	2N3638	Biasing transistor
	Q14	2N3638	Amplifier
	Q15	2N1480	Discharge transistor
	Q16	2N2945	Constant current source
	Q17	2N3638	Emitter follower
	Q18	2N3641	Emitter follower
	Q19-Q23	2N3646	NOR gates
	Q24-Q26	2N3646	Inverter
	Q27, Q28	2N3646	NOR gates
	Q29, Q30	2N3694	Darlington emitter follower
	Q31, Q32	2N3646	Schmitt trigger
	Q33	2N3646	Inverter
	Q34, Q35	2N3646, 2N3641	Difference amplifier
	Q36, Q37	2N3646	Schmitt trigger
	Q38, Q39	2N3646	Monostable multivibrator
	Q40	2N3638	Timing switch
CRT Power Supply A6	CR1, CR2	7S50	-2500V rectifiers
	CR3	7S50	+2500V rectifier
	Q1, Q2	2N1480	Oscillator

TABLE 1-2. MAIN FRAME TRANSISTOR AND CRYSTAL DIODE COMPLEMENT (Cont)

Location	Ref. Desig.	Type	Function
Power Supply Rectifier and Filter A7	CR1, CR2	MV-10C	+300V rectifiers
	CR3, CR4	1N4089	+100V rectifiers
	CR5-CR8	1N4089	+12V rectifiers
	CR9-CR12	1N4089	-12V rectifiers
Power Supply Control A8	CR1, CR2	1N4089	Voltage dropping
	CR3	1N821	Zener regulator
	CR4, CR5	1N4089	Voltage dropping
	CR6	1N821	Zener regulator
	Q1	2N3440	Emitter follower
	Q2	2N3440	Dc amplifier
	Q3, Q4	2N3440	Difference amplifier
	Q5	2N3638	Emitter follower
	Q6, Q7	2N3694	Dc amplifiers
	Q8	2N3638	Emitter follower
	Q9, Q10	2N3694	Dc amplifiers
	V1	Z82R	Gaseous regulator
Auxiliary Control A9	Q1, Q2	2N3641	Difference amplifier
	Q3, Q4	2N3641	Difference amplifier
	Q5, Q6	2N3638	Emitter followers

TABLE 1-3. MAIN FRAME FUSE COMPLEMENT

Ref. Desig.	Type	Function
A7F1	1/10 amp (Delay)	+100V power supply
A7F2	2 amp (Delay)	+12V power supply
A7F3	1-1/4 amp (Delay)	-12V power supply
F1	1-1/4 amp (Delay)	Power line
F2	1-1/4 amp (Delay)	Power line

SECTION II

OPERATION

2-1. GENERAL.

2-2. This section describes the sequence required to place the SPA-100 or SPA-100A Spectrum Analyzer into operation. The complete operating procedures, which depend upon the particular tuning unit in use, is given in a manual covering the tuning unit.

2-3. INSTALLATION.

2-4. The SPA-100 or SPA-100A Spectrum Analyzer may be used as a portable or a rack-mounted unit, and may be operated from a 115-volt or 230-volt source.

Note

When the Main Frame is used with Model RF-100 or RF-100A Tuning Head, be sure that the shorting plug is inserted into the AUXILIARY MODULE jack J2, and a jumper cable is connected between the IF OUTPUT and IF INPUT jacks. These jacks are located on the rear panel of the Main Frame.

2-5. To operate the Main Frame from a source of a-c power, first determine the line voltage and set AC INPUT switch (see figure 2-1) to the corresponding position, either 115V for operation from a 103 to 127 volt line or 230V for operation from 206 to 254 volt line. Th AC INPUT switch is located on the rear of the Main Frame.

(To be supplied)

Figure 2-1. Main Frame, Rear View

Caution

If the AC INPUT switch is set to 115V, and the equipment is to be operated from the 103 to 127 volt a-c line, the input power circuitry should be protected with the supplied 1.25 ampere, 115v, delay type, fuses F1 and F2 (figure 2-1); if the unit is converted to 206 to 254 a-c operation (by setting the AC INPUT switch to 230V), the 1.25 ampere fuses should be replaced by 7/10 ampere fuses. Failure to perform this replacement may cause damage to the power supply circuitry.

2-6. After ensuring that the AC INPUT switch is in the correct position and that fuses F1 and F2 are of the proper value, the a-c line cord (figure 2-1) may be connected to the appropriate power source. If the external power source does not accommodate the 3-pin a-c plug provided, use the 3-wire to 2-wire adapter plug supplied. When the adapter plug is used, make certain the ground wire is connected to a suitable ground.

Warning

Failure to properly ground the equipment may result in injury to personnel.

2-7. To install the Main Frame in a standard equipment rack, perform the following:

a. Secure the mounting ears to the sides of the cabinet (refer to figure 2-2).

b. If slides are to be used, connect them to the cabinet and the rack. If slides are not to be used, provide an angle bracket near the rear of the rack to support the rear of the Main Frame.

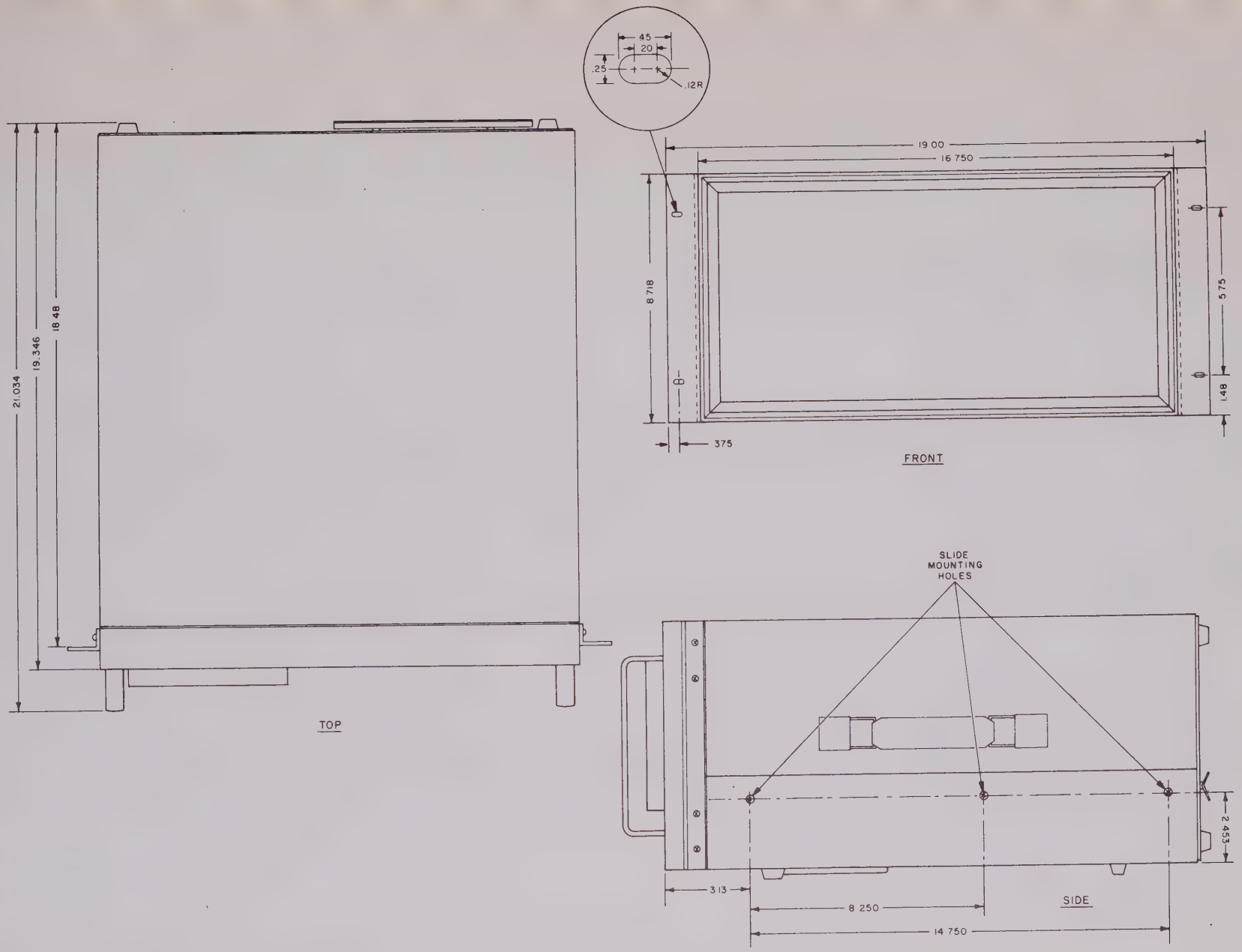
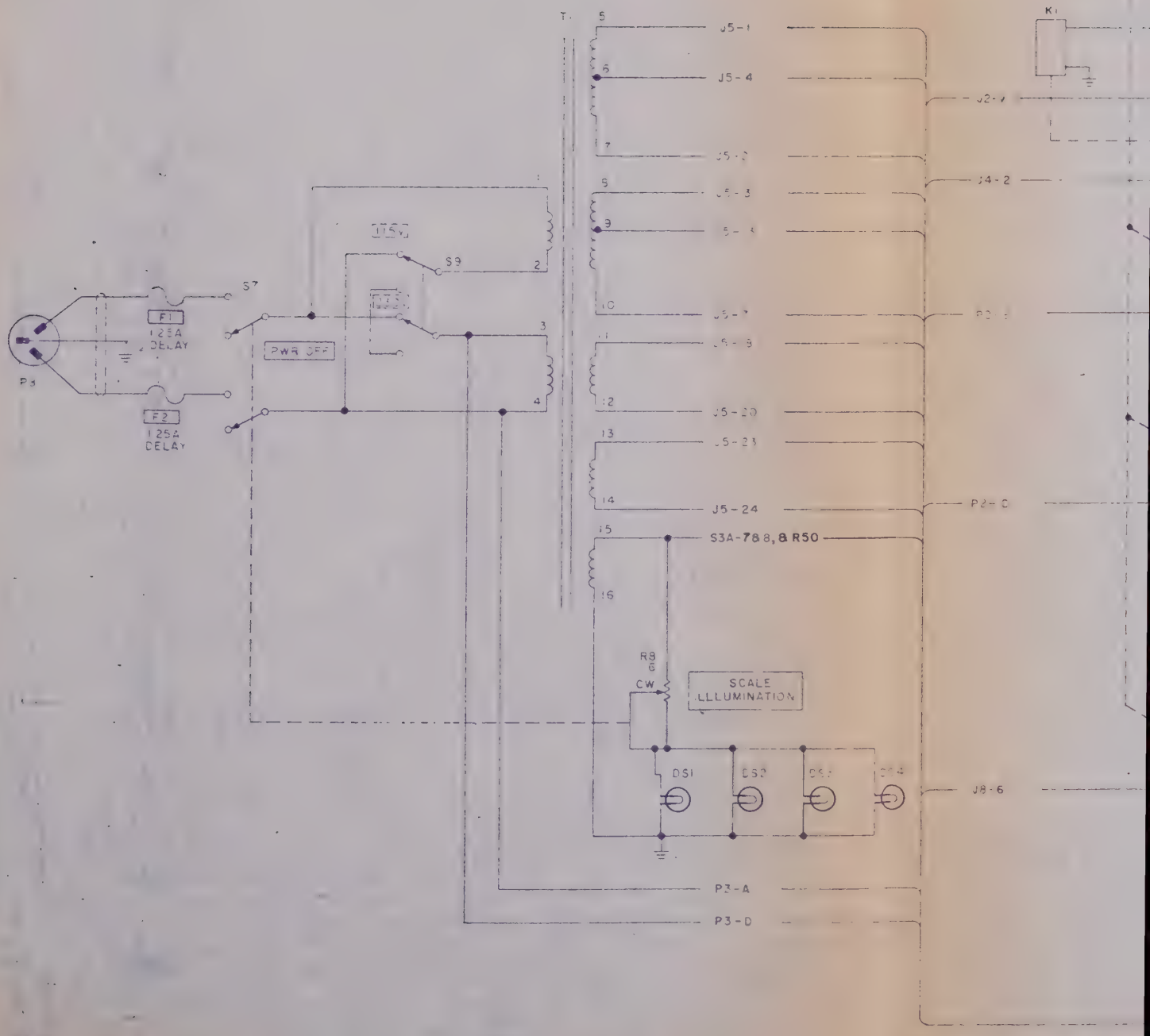


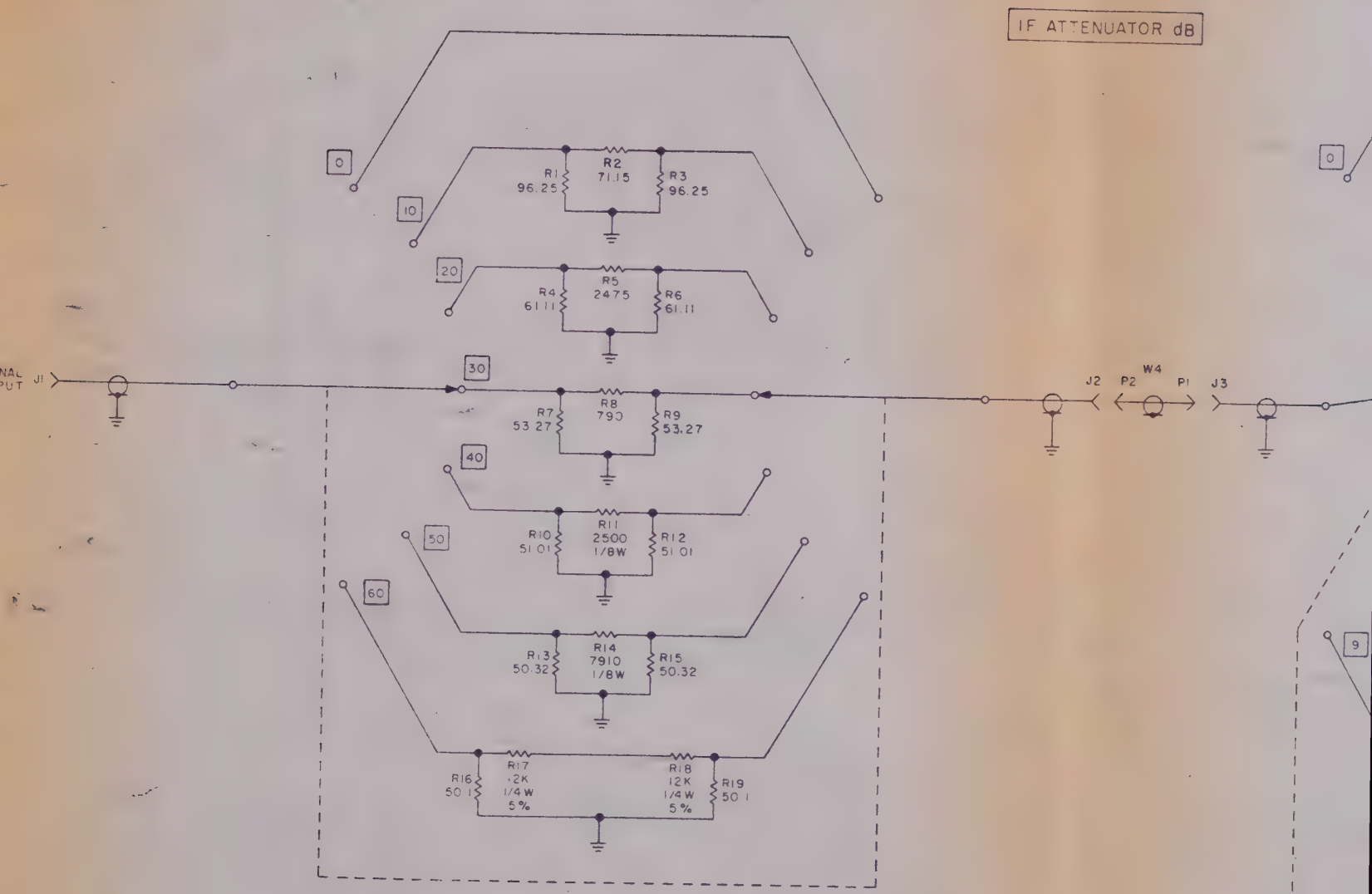
Figure 2-2. Outline Dimension Drawing

Note

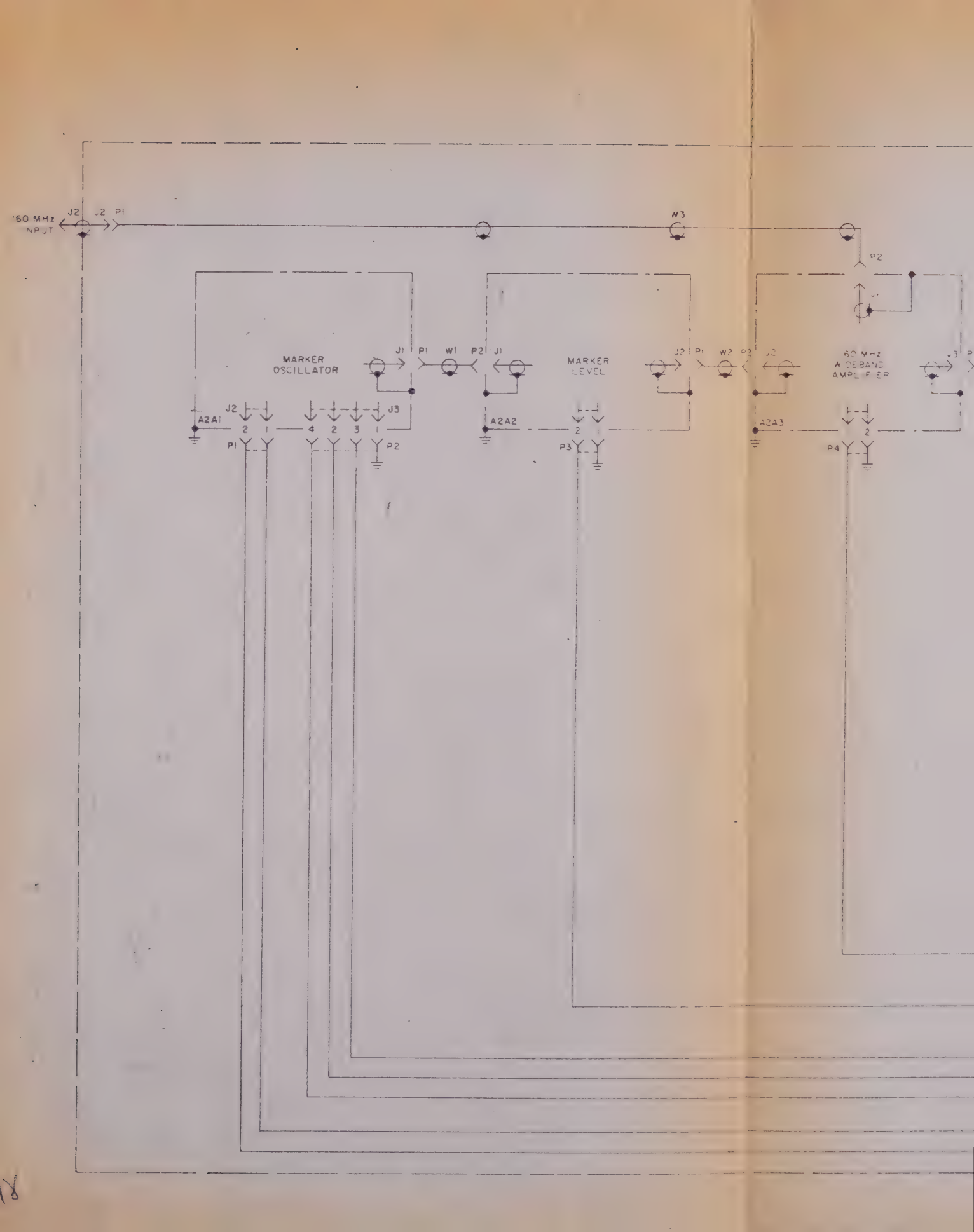
The mounting ears should not be used to support the full weight of the unit.

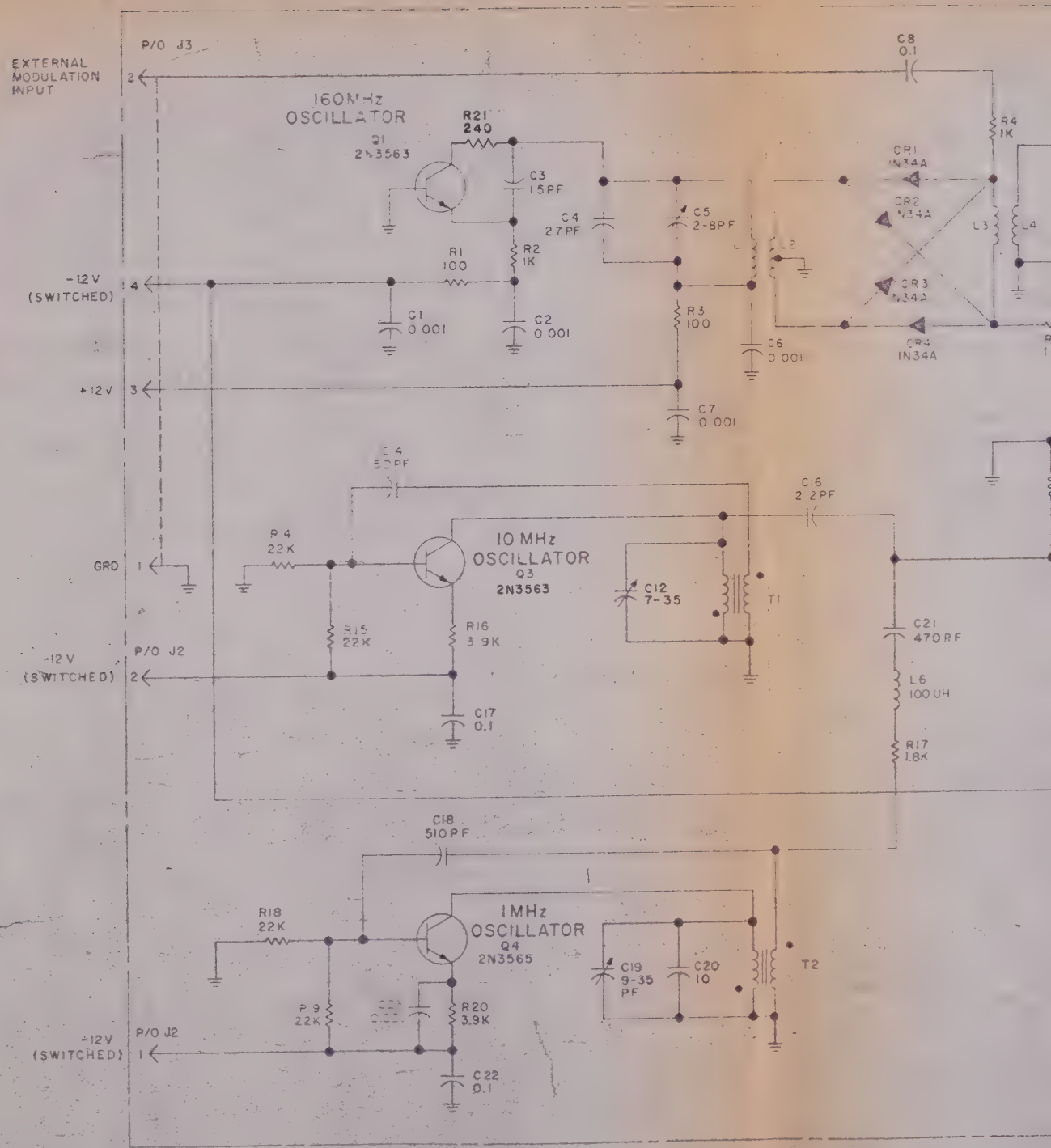
2-8. Heat dissipation from the Main Frame or installed tuning head need not be considered since the solid state design (Model RF-100 and RF-100A each have only one low-power electron tube) reduces heat to a negligible extent.

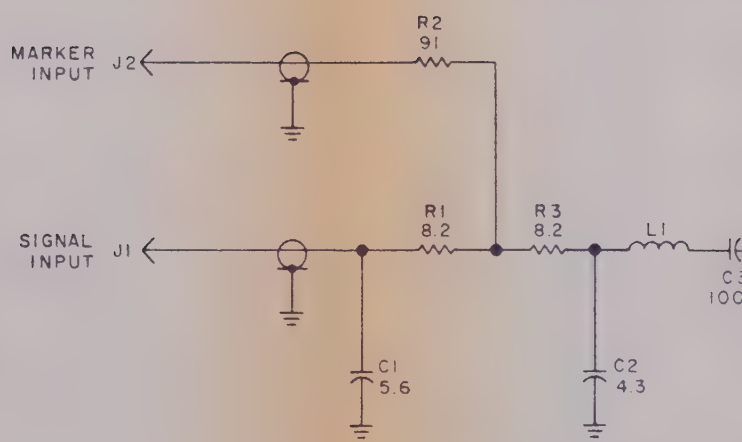

BANDWIDT
K-Z
S
K1
T1
J5-1
J5-4
J5-2
J5-3
J5-7
J5-8
J5-20
J5-23
J5-24
S3A-7B8, 8R50
J2-7
J4-2
P2-C
J8-6
P3-A
P3-D
S7
S9
115V
230V
PWR OFF
F1
1.25A
DELAY
F2
1.25A
DELAY
P3
R8
CW
SCALE
ILLUMINATION
DS1
DS2
DS3
DS4

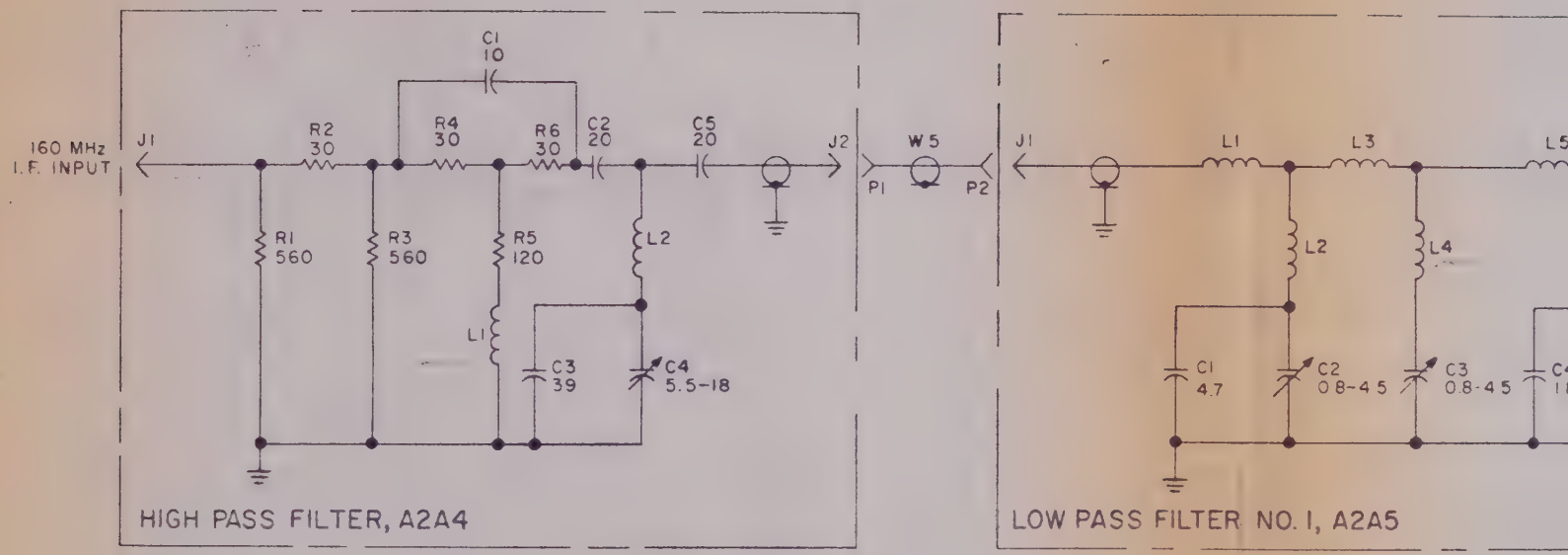


NOTE:
UNLESS OTHERWISE SPECIFIED:
1. ALL RESISTORS ARE IN OHMS, 1/10W, 1%.


60 MHz
INPUT
J2
J2
P1
W3
P2
MARKER
OSCILLATOR
J1
P1
W1
P2
J1
MARKER
LEVEL
J2
P1
W2
P2
J2
60 MHz
WIDEBAND
AMPLIFIER
J3
A2A1
J2
2
1
4
2
3
1
J3
P1
P2
A2A2
2
1
P3
A2A3
1
2
P4


EXTERNAL MODULATION INPUT
P/O J3
2
160 MHz OSCILLATOR
Q1 2N3563
R21 240
C3 15PF
C4 27PF
C5 2-8PF
C8 0.1
R4 1K
CR1 IN34A
CR2 IN34A
CR3 IN34A
CR4 IN34A
L3
L4
L2
R1 100
R2 1K
R3 100
C1 0.001
C2 0.001
C6 0.001
C7 0.001
-12V (SWITCHED)
4
+12V
3
GRD
1
C14 50PF
C16 2.2PF
R14 22K
10 MHz OSCILLATOR
Q3 2N3563
C12 7-35
T1
R15 22K
R16 3.9K
C17 0.1
C21 470PF
L6 100UH
R17 1.8K
-12V (SWITCHED)
P/O J2
2
C18 510PF
R18 22K
1MHz OSCILLATOR
Q4 2N3565
C19 9-35 PF
C20 10
T2
R19 22K
R20 3.9K
C22 0.1
-12V (SWITCHED)
P/O J2
1

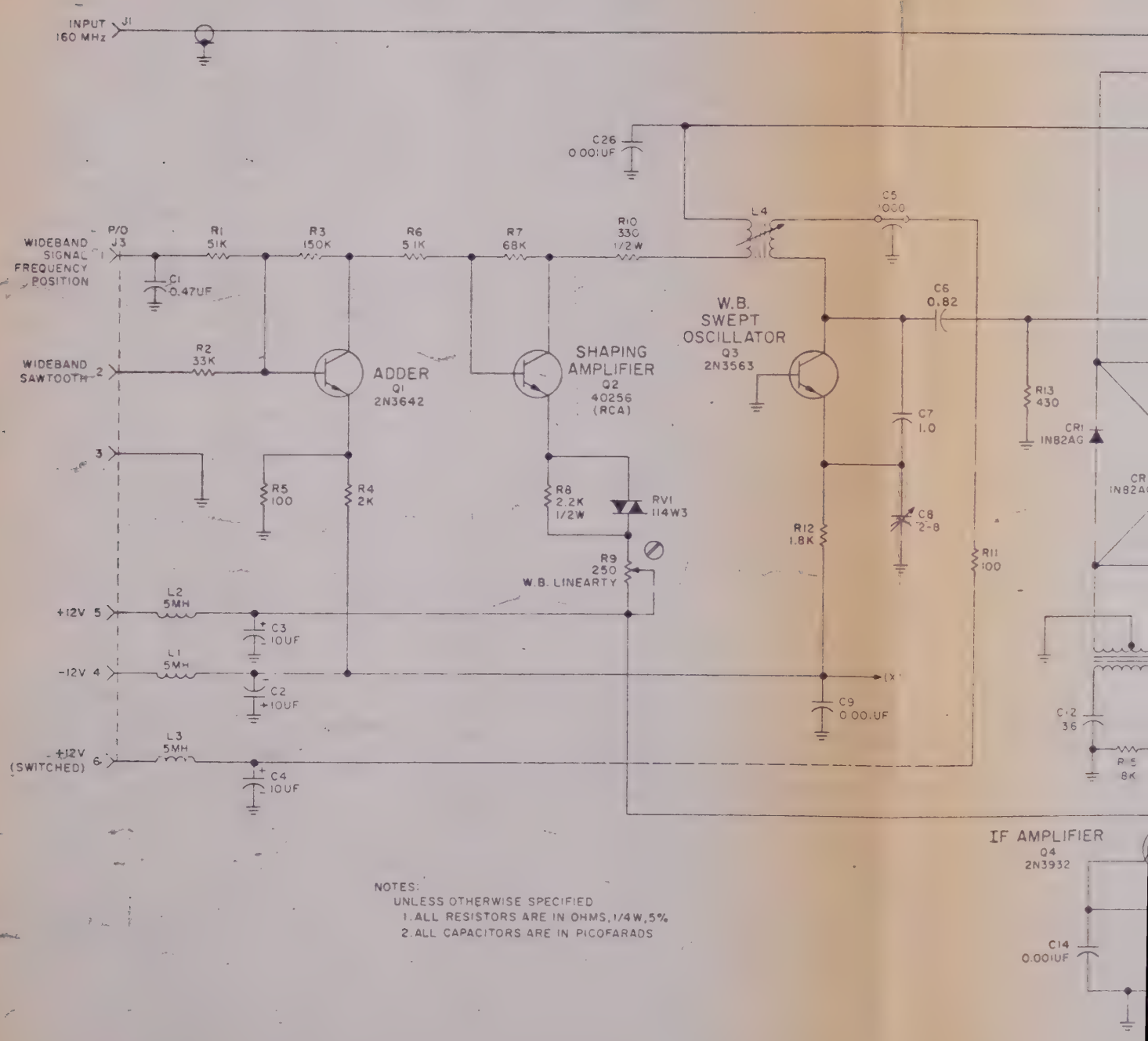

MARKER INPUT
J2
R2
91
SIGNAL INPUT
J1
R1
8.2
R3
8.2
L1
C1
5.6
C2
4.3



NOTES:

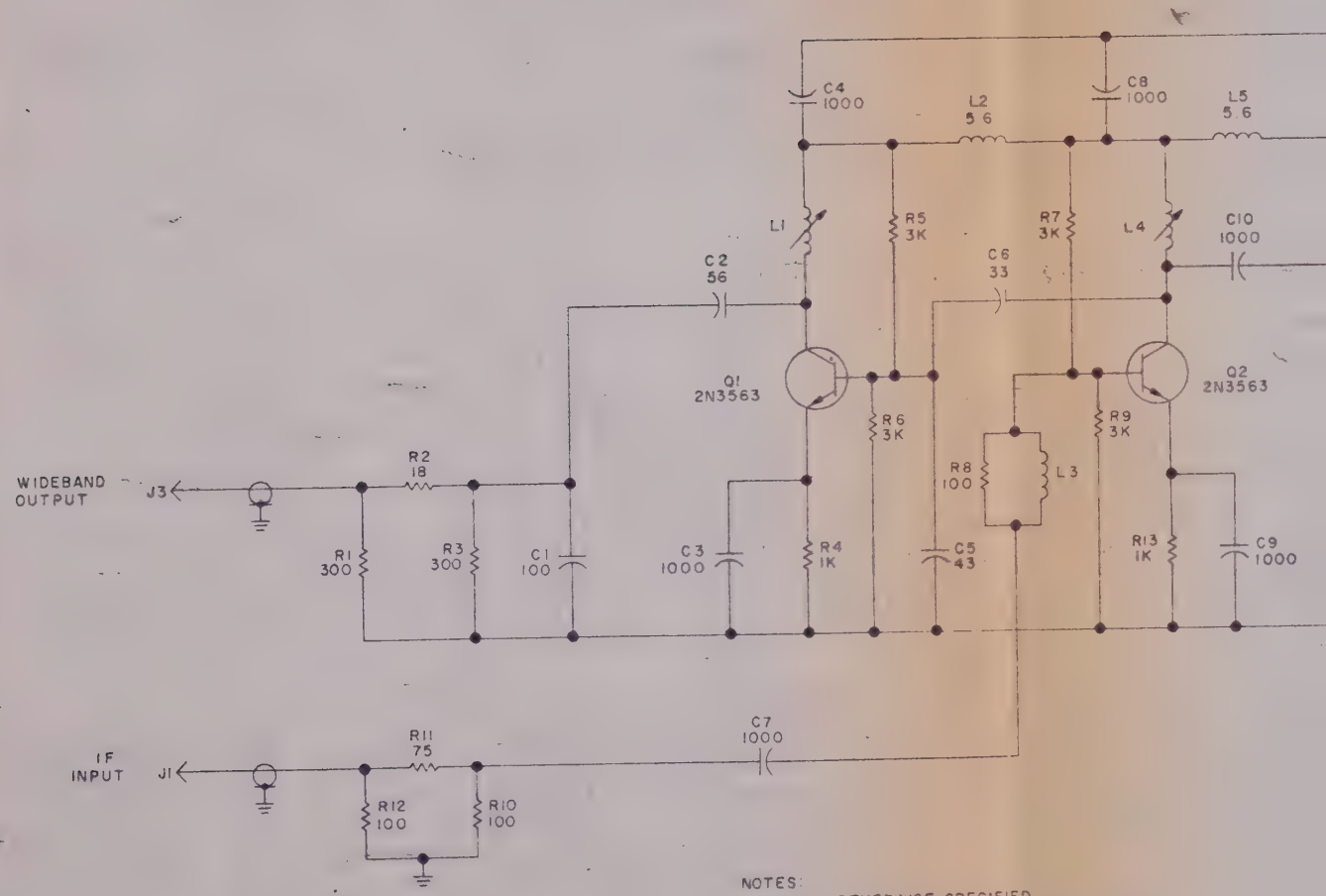
UNLESS OTHERWISE SPECIFIED,

1. ALL RESISTORS ARE IN OHMS, 1/4W, 5%
2. ALL CAPACITORS ARE IN PICOFARADS.

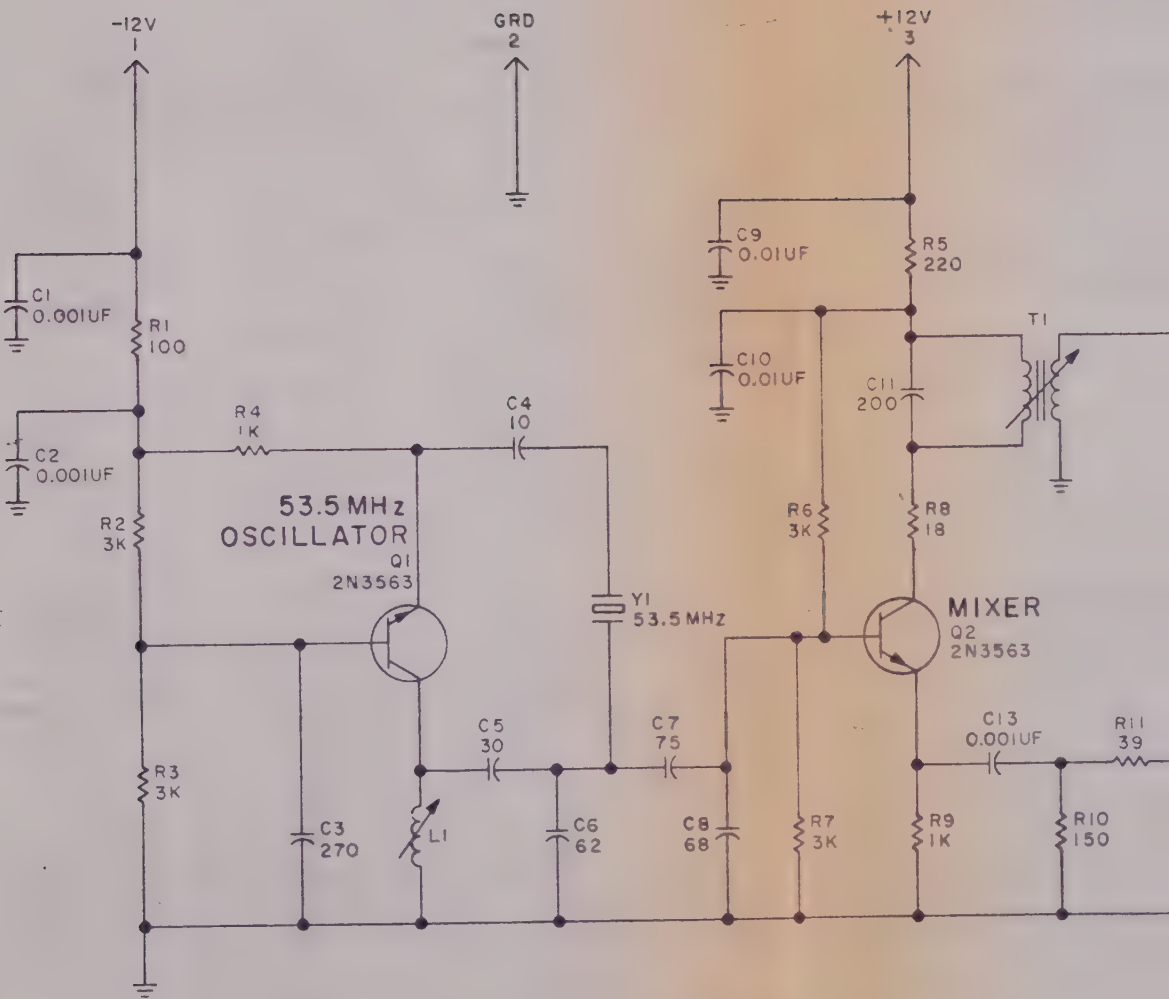


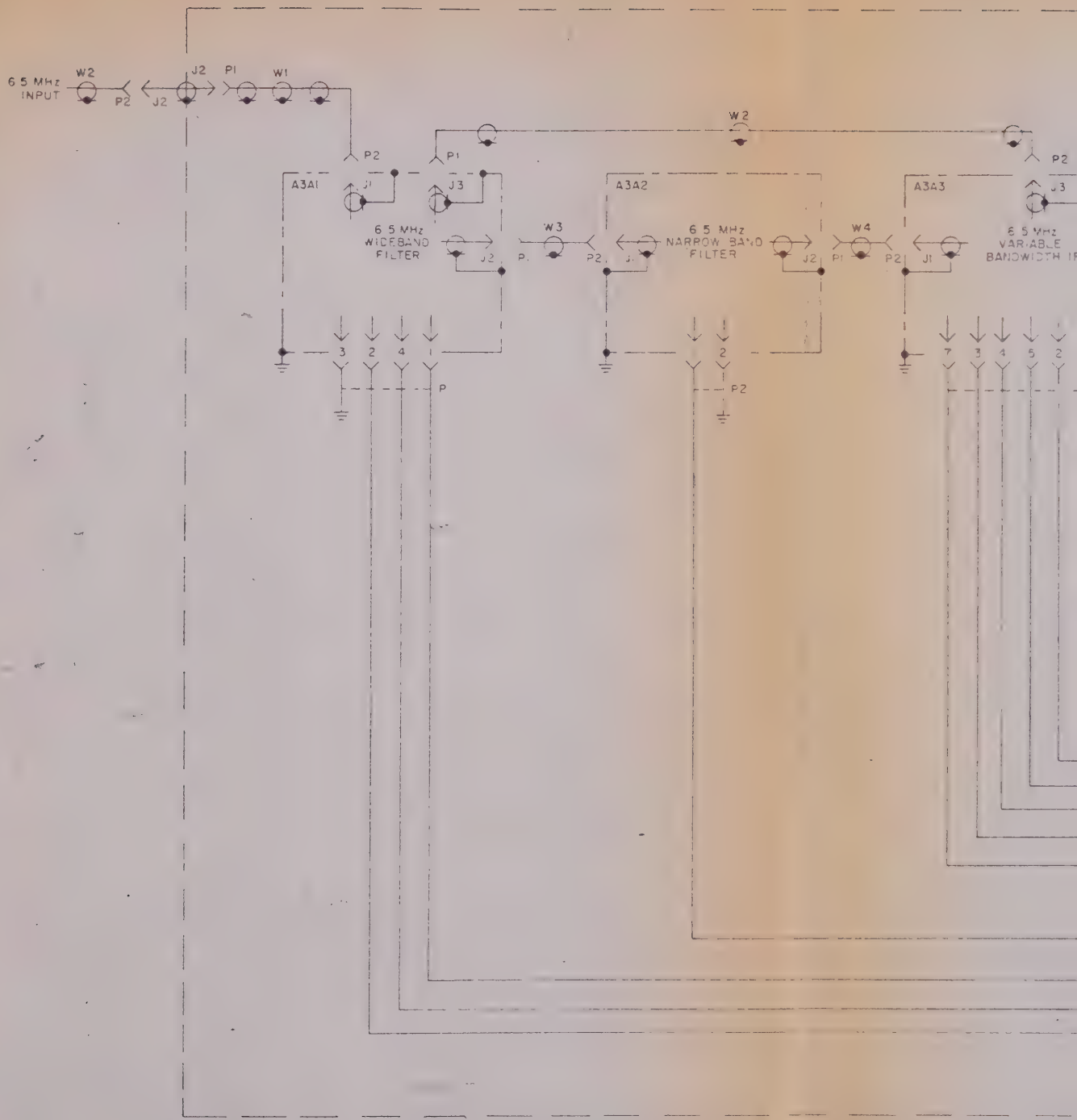
NOTES:
UNLESS OTHERWISE SPECIFIED
1. ALL RESISTORS ARE IN OHMS, 1/4W, 5%
2. ALL CAPACITORS ARE IN PICOFARADS

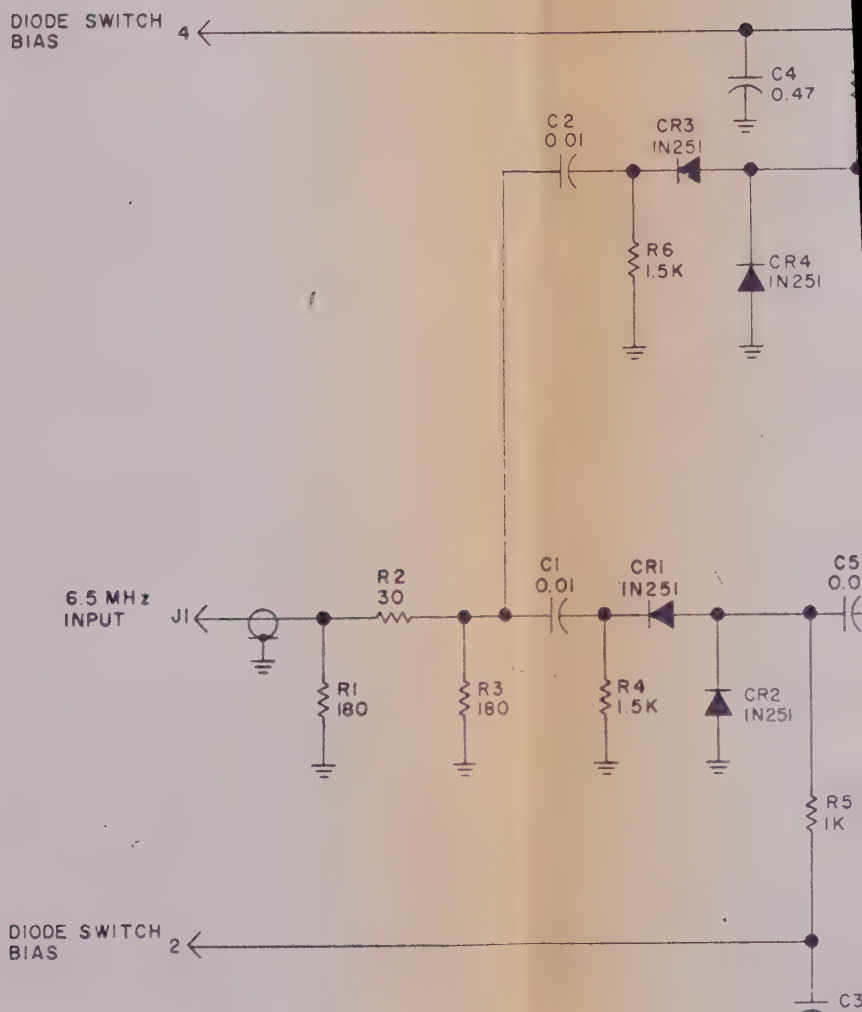
60 MHz AMPL

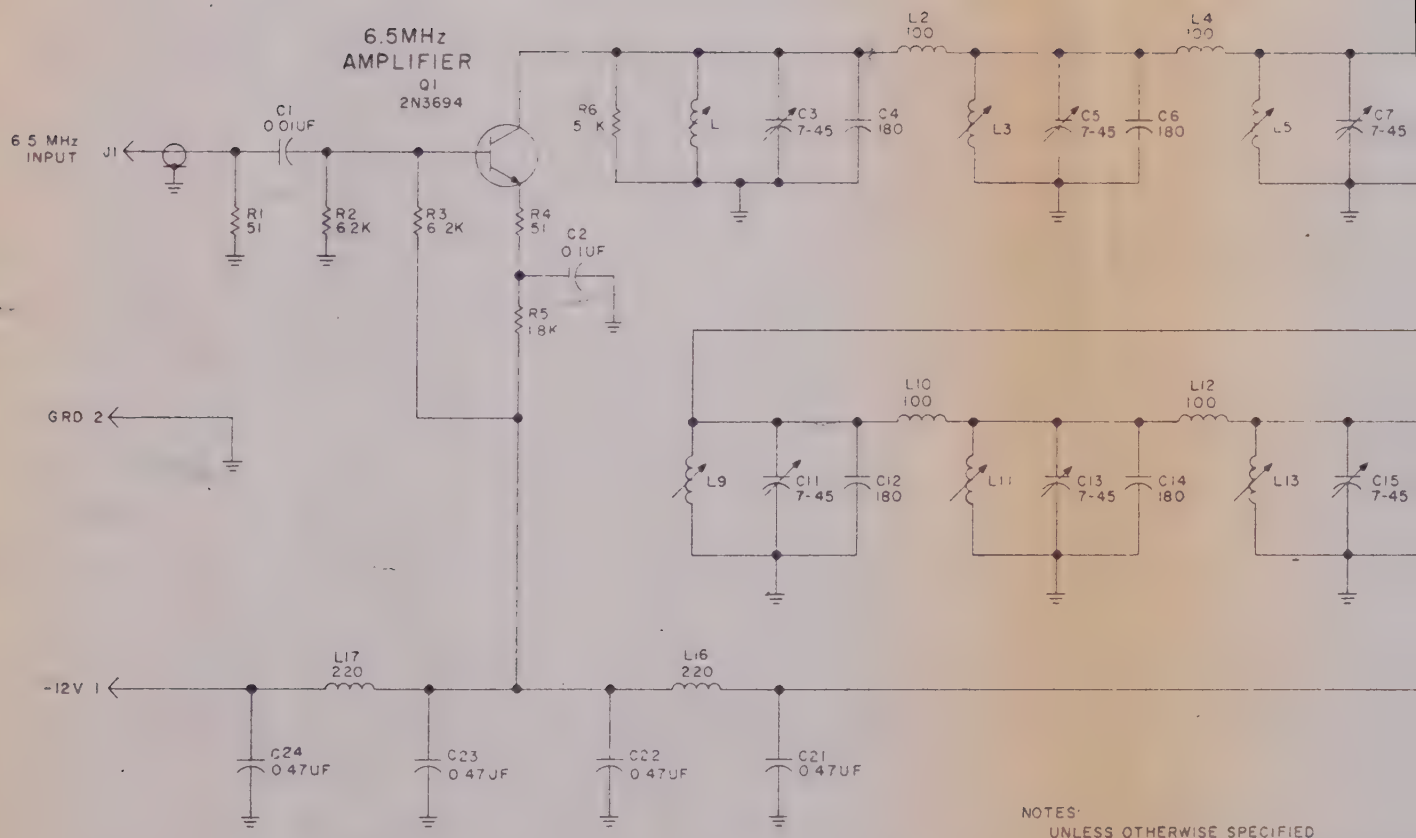


NOTES:
UNLESS OTHERWISE SPECIFIED
1. ALL RESISTORS ARE IN OHMS, 1/4 W, 5%
2. ALL CAPACITORS ARE IN PICOFARADS
3. ALL INDUCTORS ARE IN MICROHENRIES.

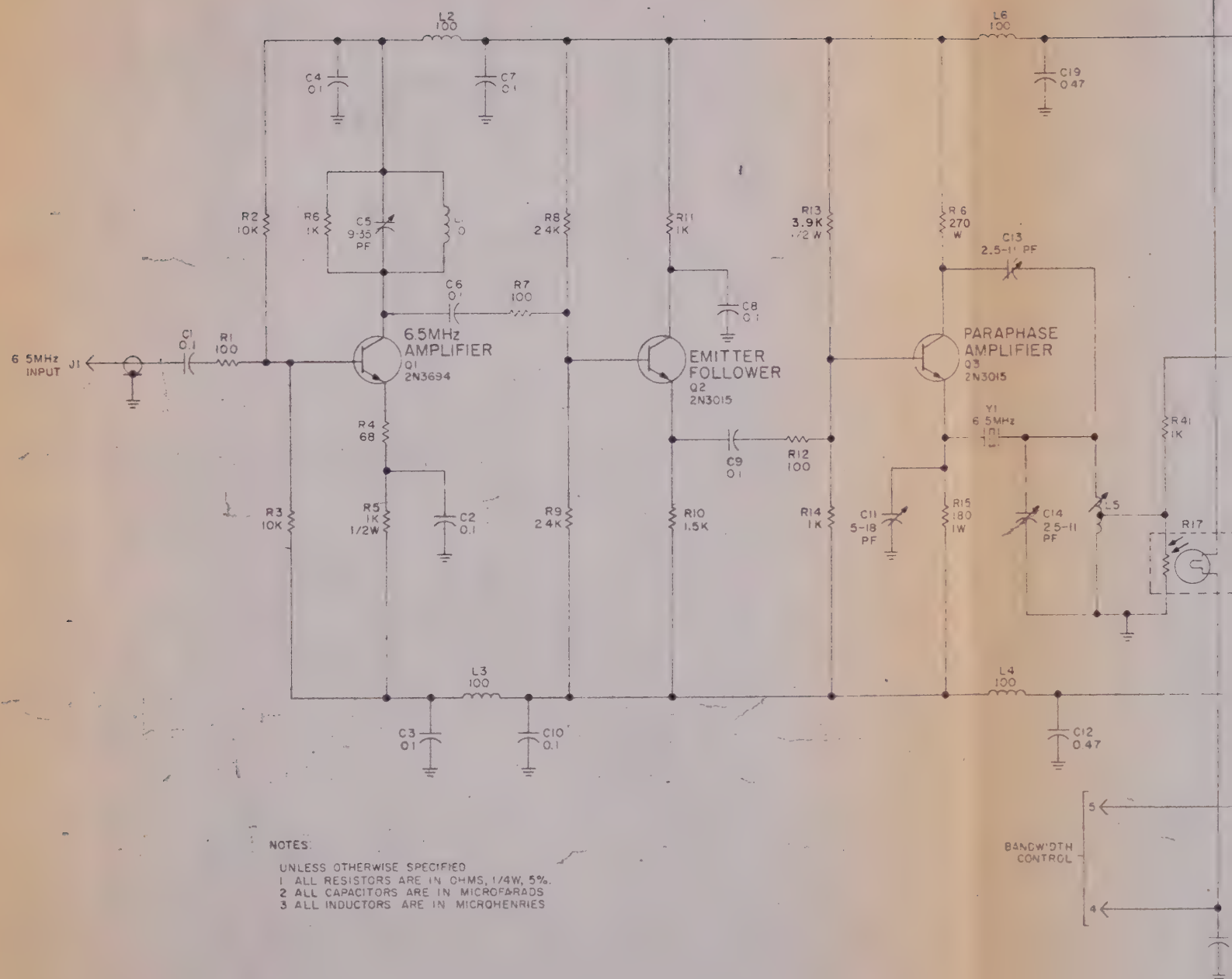

-12V
1
GRD
2
+12V
3
C1
0.001UF
R1
100
C2
0.001UF
R2
3K
R3
3K
R4
1K
C4
10
53.5 MHz
OSCILLATOR
Q1
2N3563
Y1
53.5 MHz
C5
30
C7
75
C3
270
L1
C6
62
C8
68
C9
0.01UF
R5
220
C10
0.01UF
T1
C11
200
R6
3K
R8
18
MIXER
Q2
2N3563
C13
0.001UF
R11
39
R7
3K
R9
1K
R10
150


6.5 MHz INPUT
W2
P2
J2
J2
P1
W1
P2
P1
W2
A3A1
J1
J3
6.5 MHz WIDEBAND FILTER
J2
P1
W3
P2
A3A2
J1
6.5 MHz NARROW BAND FILTER
J2
P1
W4
P2
A3A3
J1
6.5 MHz VARIABLE BANDWIDTH IF
J3
3
2
4
1
P
2
P2
7
3
4
5
2


DIODE SWITCH BIAS
4
C4
0.47
C2
0.01
CR3
IN251
R6
1.5K
CR4
IN251
6.5 MHz
INPUT
J1
R2
30
C1
0.01
CR1
IN251
R1
180
R3
180
R4
1.5K
CR2
IN251
R5
1K
DIODE SWITCH BIAS
2



NOTES:
UNLESS OTHERWISE SPECIFIED
1. ALL RESISTORS ARE IN OHMS, 1/4 W
2. ALL CAPACITORS ARE IN PICOFARADS
3. ALL INDUCTORS ARE IN MICROHENRI



NOTES:

UNLESS OTHERWISE SPECIFIED
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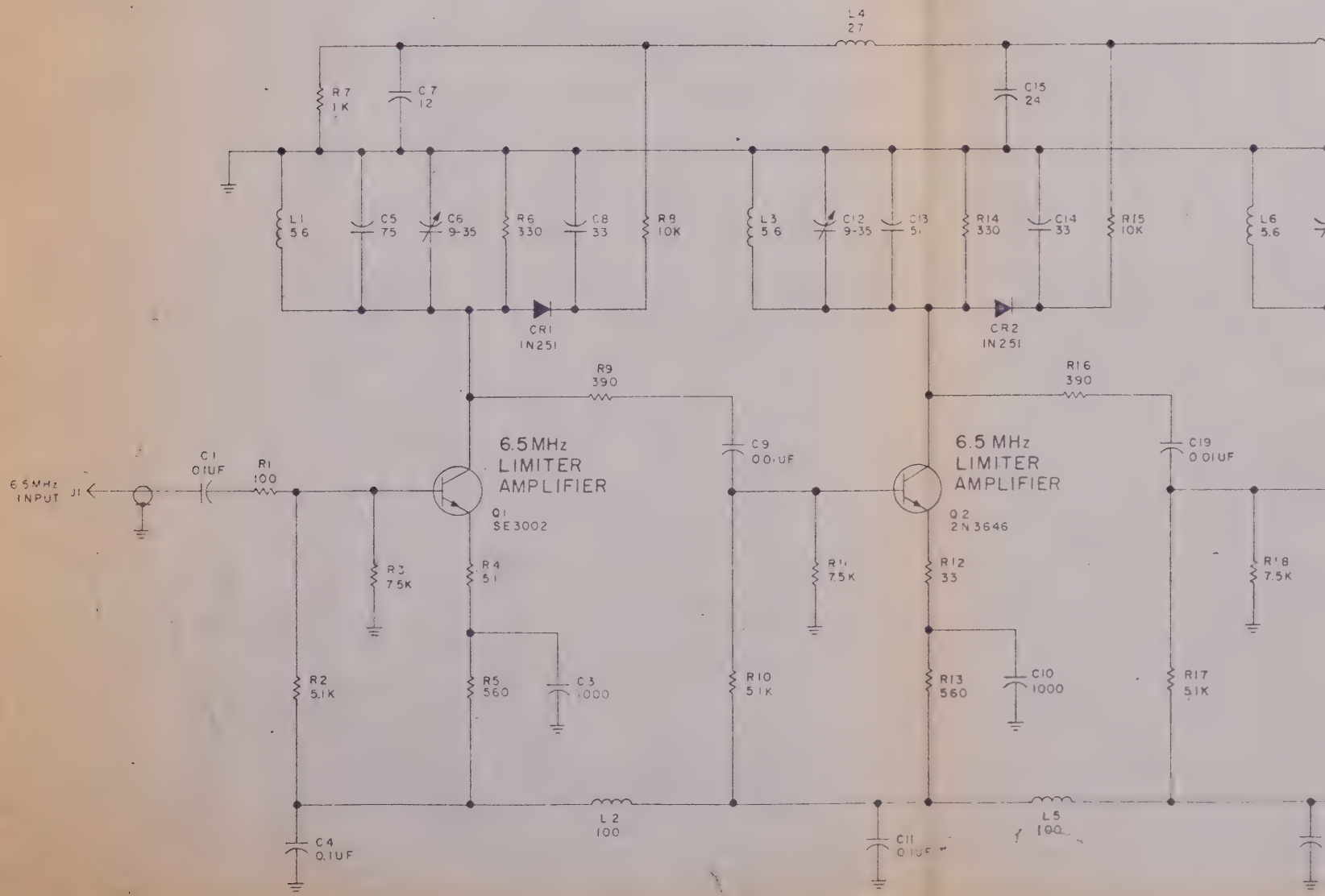
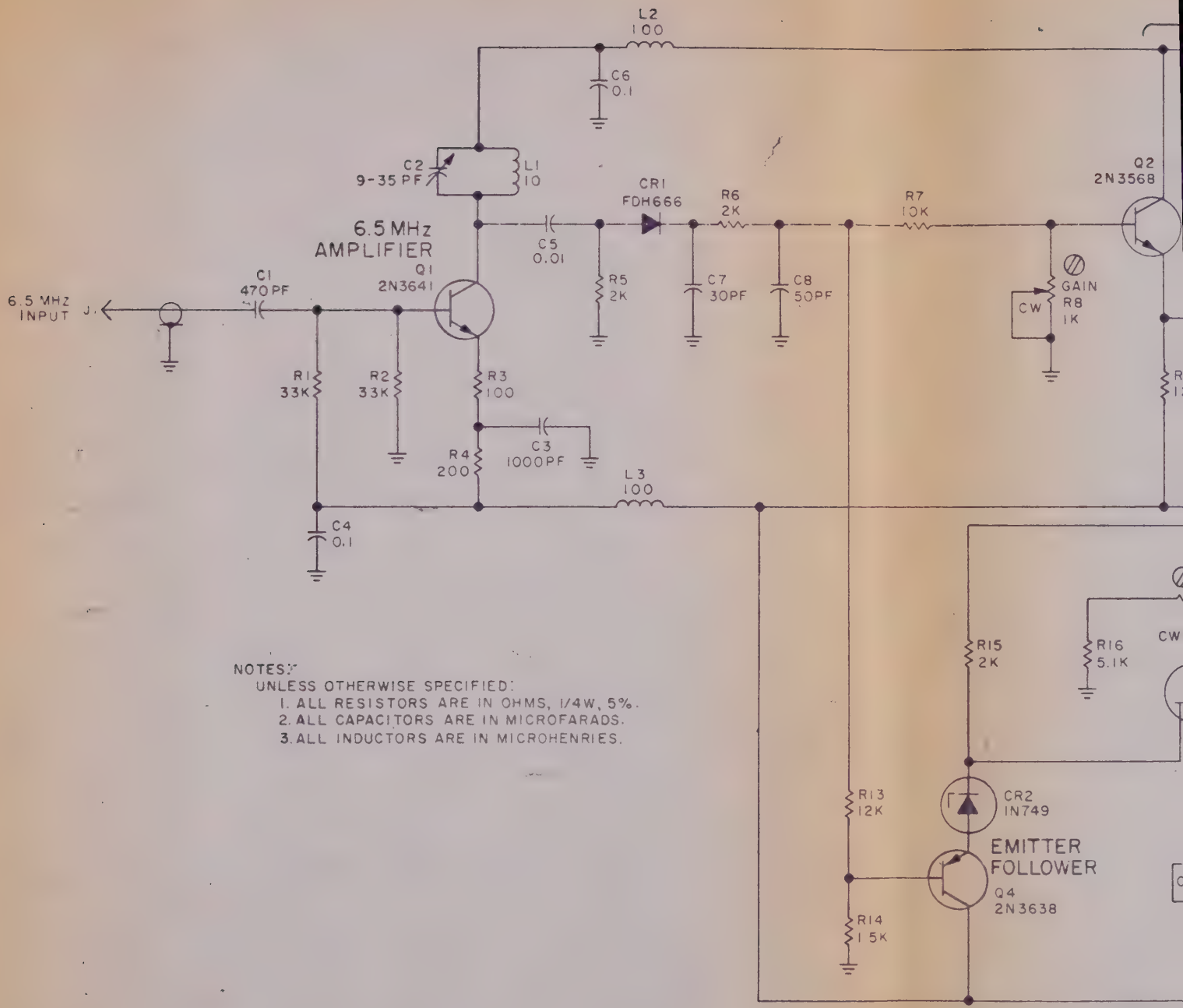
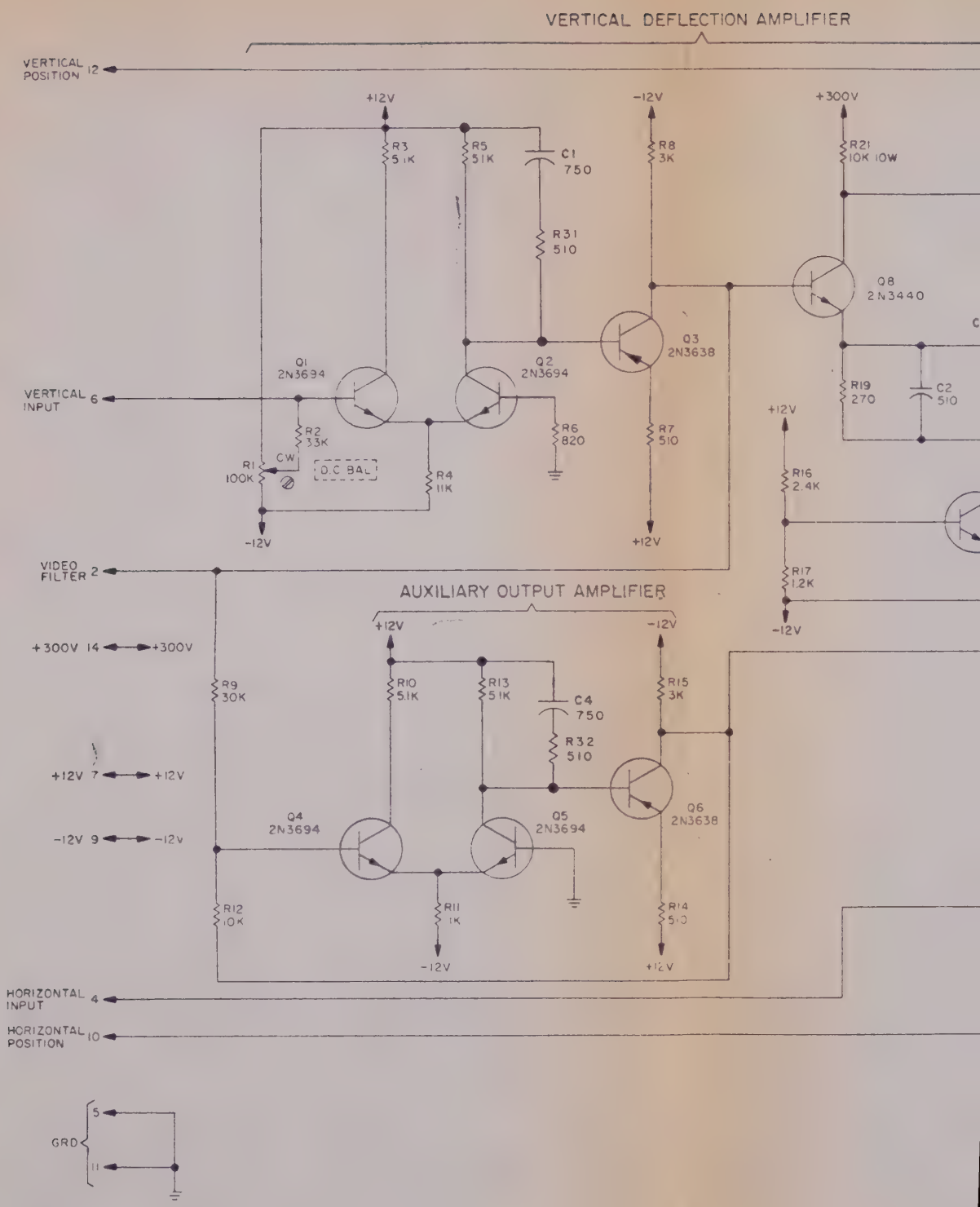
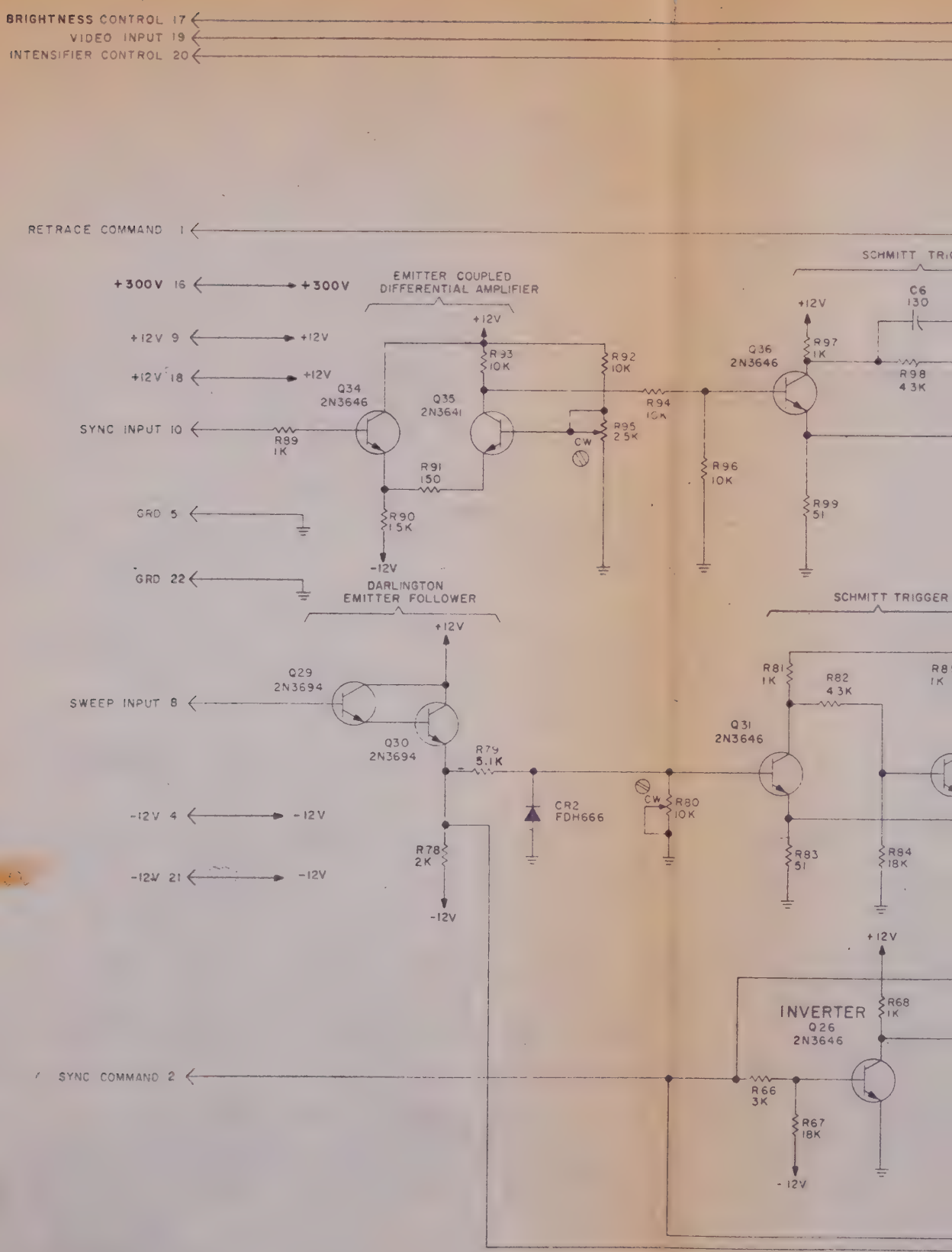
2 ALL CAPACITORS ARE IN MICROFARADS
3 ALL INDUCTORS ARE IN MICROHENRIES

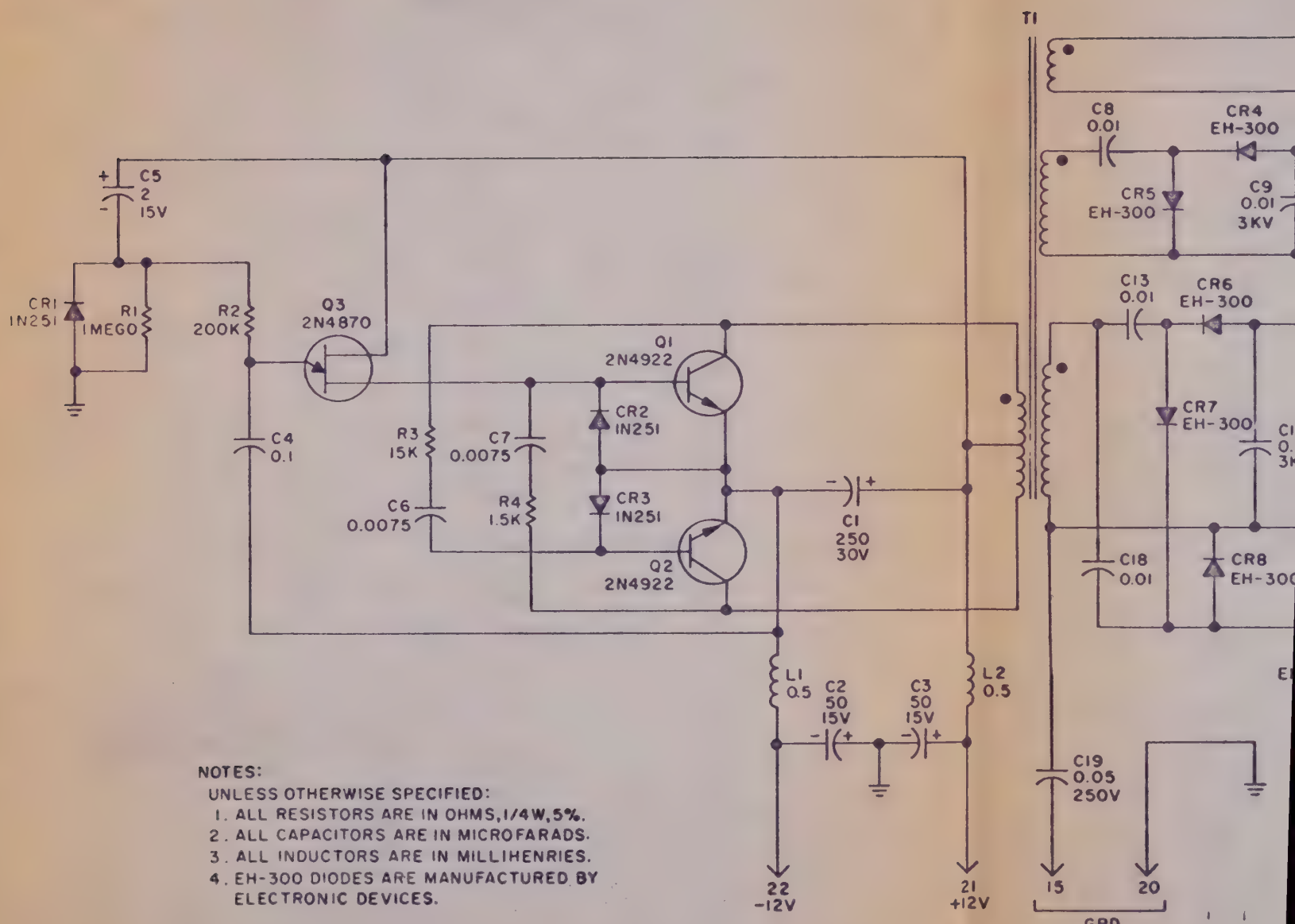

L4
27
R7
1K
C7
12
C15
24
L1
5.6
C5
75
C6
9-35
R6
330
C8
33
R8
10K
L3
5.6
C12
9-35
C13
5
R14
330
C14
33
R15
10K
L6
5.6
CR1
IN251
CR2
IN251
R9
390
R16
390
6.5MHz
INPUT
J1
C1
0.1UF
R1
100
6.5MHz
LIMITER
AMPLIFIER
Q1
SE3002
6.5 MHz
LIMITER
AMPLIFIER
Q2
2N3646
C9
0.01UF
C19
0.01UF
R3
7.5K
R4
51
R11
7.5K
R12
33
R18
7.5K
R2
5.1K
R5
560
C3
1000
R10
5.1K
R13
560
C10
1000
R17
5.1K
L2
100
L5
100
C4
0.1UF
C11
0.1UF



NOTES:
UNLESS OTHERWISE SPECIFIED:
1. ALL RESISTORS ARE IN OHMS, 1/4W, 5%.
2. ALL CAPACITORS ARE IN MICROFARADS.
3. ALL INDUCTORS ARE IN MICROHENRIES.

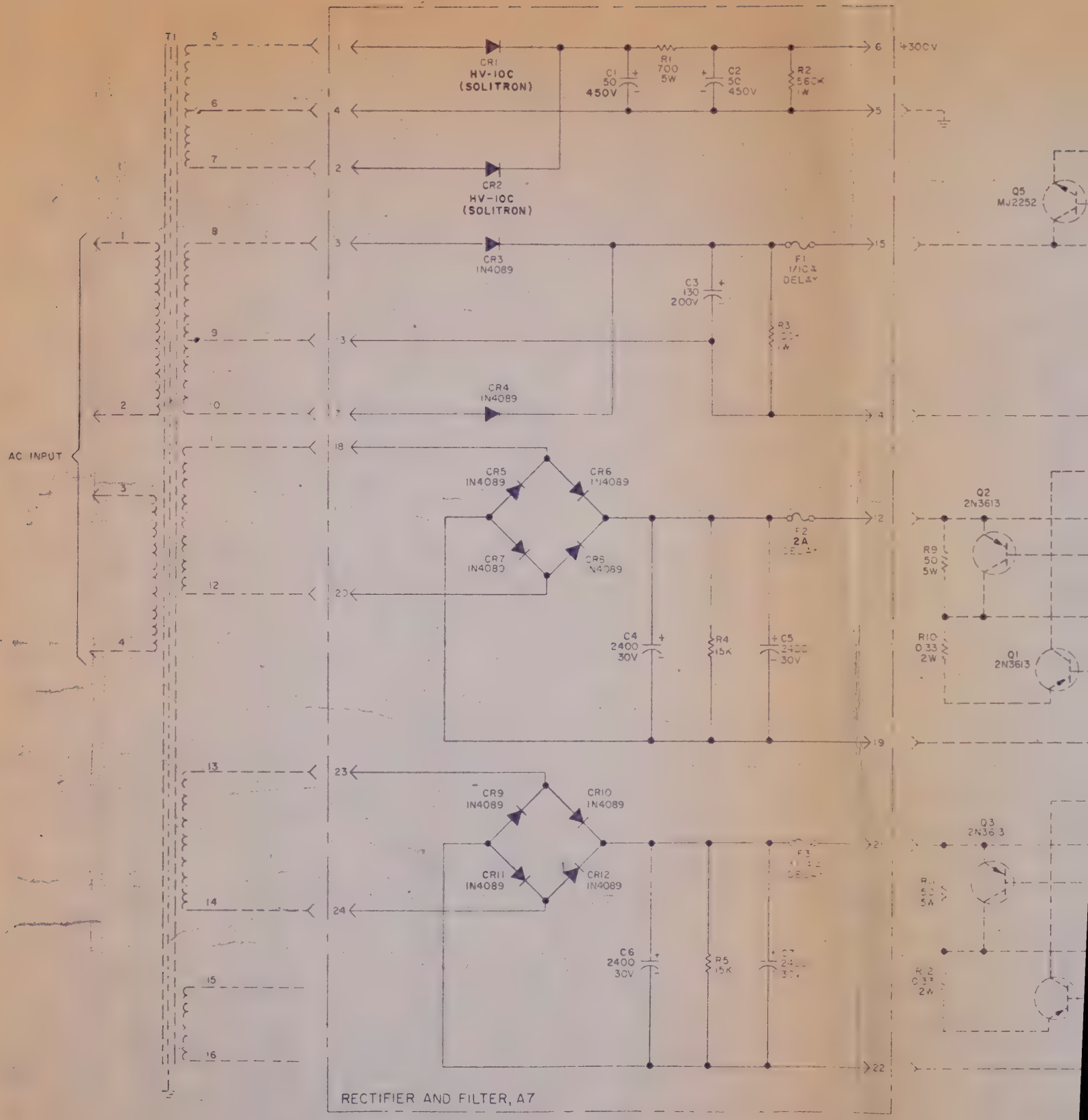

VERTICAL DEFLECTION AMPLIFIER
VERTICAL POSITION 12
+12V
-12V
+300V
R3 5.1K
R5 5.1K
C1 750
R8 3K
R21 10K 10W
R31 510
Q8 2N3440
Q3 2N3638
Q1 2N3694
Q2 2N3694
VERTICAL INPUT 6
R19 270
C2 510
R2 33K
R6 820
R7 510
R1 100K
CW
D.C. BAL
R4 11K
R16 2.4K
VIDEO FILTER 2
R17 1.2K
AUXILIARY OUTPUT AMPLIFIER
+300V 14
+300V
R9 30K
R10 5.1K
R13 5.1K
C4 750
R15 3K
R32 510
+12V 7
+12V
-12V 9
-12V
Q4 2N3694
Q5 2N3694
Q6 2N3638
R12 10K
R11 1K
R14 510
HORIZONTAL INPUT 4
HORIZONTAL POSITION 10
GRD
5
11

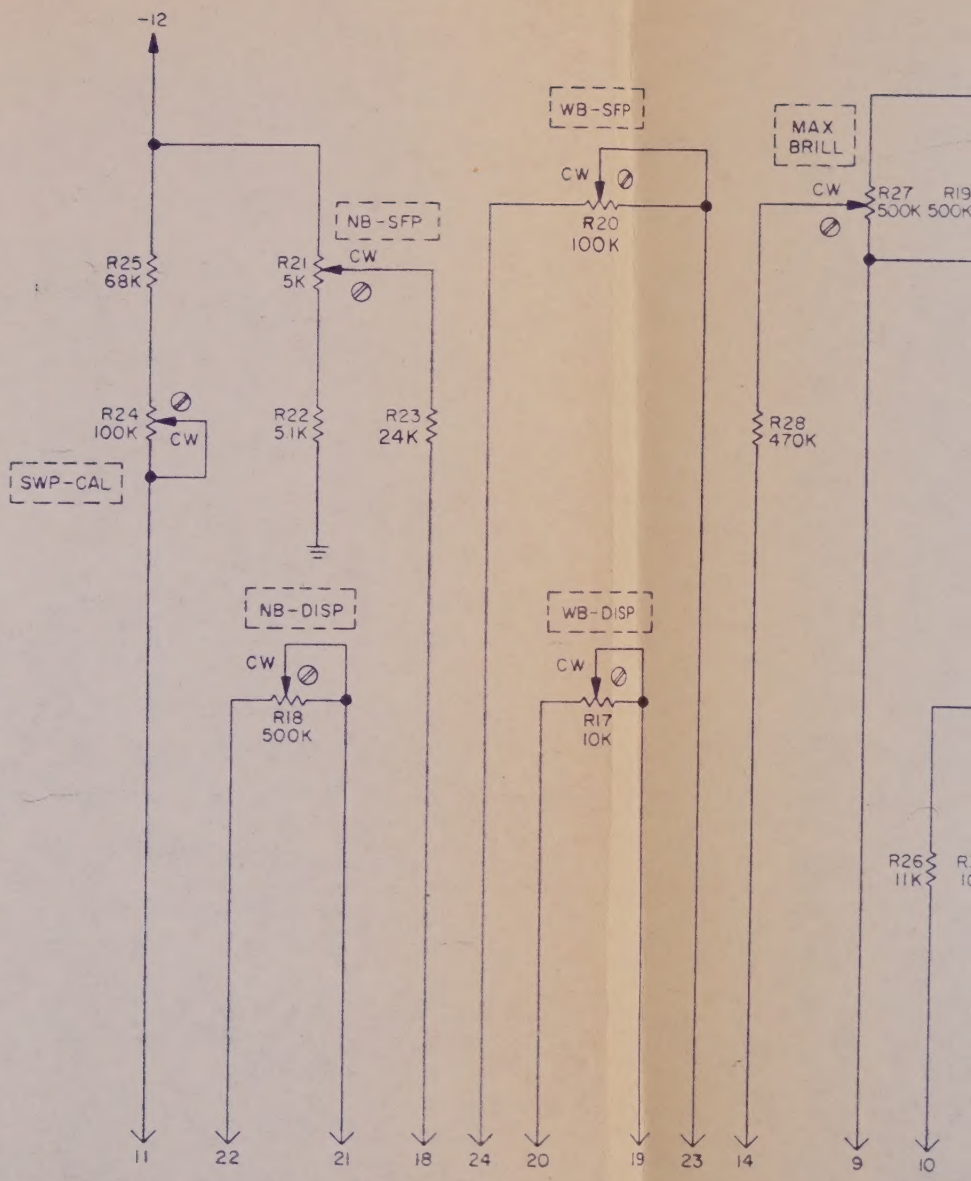

BRIGHTNESS CONTROL 17
VIDEO INPUT 19
INTENSIFIER CONTROL 20
RETRACE COMMAND 1
+300V 16
+300V
+12V 9
+12V
+12V 18
+12V
SYNC INPUT 10
GRD 5
GRD 22
-12V 4
-12V
-12V 21
-12V
SYNC COMMAND 2
EMITTER COUPLED DIFFERENTIAL AMPLIFIER
DARLINGTON EMITTER FOLLOWER
SCHMITT TRIGGER
SCHMITT TRI
Q34 2N3646
Q35 2N3641
Q36 2N3646
Q29 2N3694
Q30 2N3694
Q31 2N3646
INVERTER Q26 2N3646
R89 1K
R90 1.5K
R91 150
R92 10K
R93 10K
R94 10K
R95 2.5K
CW
R96 10K
R97 1K
R98 4.3K
R99 51
C6 130
R78 2K
R79 5.1K
CR2 FDH666
CW
R80 10K
R81 1K
R82 4.3K
R83 51
R84 18K
R66 3K
R67 18K
R68 1K



NOTES:
UNLESS OTHERWISE SPECIFIED:

1. ALL RESISTORS ARE IN OHMS, 1/4W, 5%.
2. ALL CAPACITORS ARE IN MICROFARADS.
3. ALL INDUCTORS ARE IN MILLIHENRIES.
4. EH-300 DIODES ARE MANUFACTURED BY ELECTRONIC DEVICES.


T1
AC INPUT
CR1
HV-10C
(SOLITRON)
CR2
HV-10C
(SOLITRON)
R1
700
5W
C1
50
450V
C2
50
450V
R2
560K
1W
+300V
Q5
MJ2252
CR3
IN4089
C3
130
200V
F1
1/10A
DELAY
R3
CR4
IN4089
CR5
IN4089
CR6
IN4089
CR7
IN4089
CR8
IN4089
F2
2A
Q2
2N3613
R9
50
5W
R10
0.33
2W
Q1
2N3613
C4
2400
30V
R4
15K
C5
30V
CR9
IN4089
CR10
IN4089
CR11
IN4089
CR12
IN4089
Q3
2N3613
C6
2400
30V
R5
15K
RECTIFIER AND FILTER, A7



INDICATES INTE

NOTE:
ALL RESISTORS